HANDBOOK
of
STANDARD DETAILS

CHARLES H. HUGHES

HANDBOOK OF STANDARD DETAILS

FOR ENGINEERS, DRAFTSMEN AND STUDENTS

BY

CHARLES H. HUGHES

AUTHOR OF "HANDBOOK OF SHIP CALCULATIONS, CONSTRUCTION AND OPERATION"

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PREFACE

This book was compiled especially for engineers and draftsmen, so they might have, in convenient form, drawings, tables, and formulæ of standard details for use in designing.

The data have been obtained from a variety of sources. Many of the tables have been furnished by the leading machine-tool manufacturers in the United States and represent their current practice.

Besides being of use to engineers and draftsmen, students, purchasing agents, and others interested in mechanical engineering will find the book of value.

CHAS. H. HUGHES

NEW YORK.

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HANDBOOK OF STANDARD DETAILS

HANDBOOK OF STANDARD DETAILS

SECTION I

DRAWINGS

NOTES ON SHOP DRAWINGS—LIMIT STANDARDS—U. S. PATENT OFFICE DRAWINGS—SHRINKAGE OF CASTINGS—GEOMETRICAL CONSTRUCTIONS

NOTES ON SHOP DRAWINGS

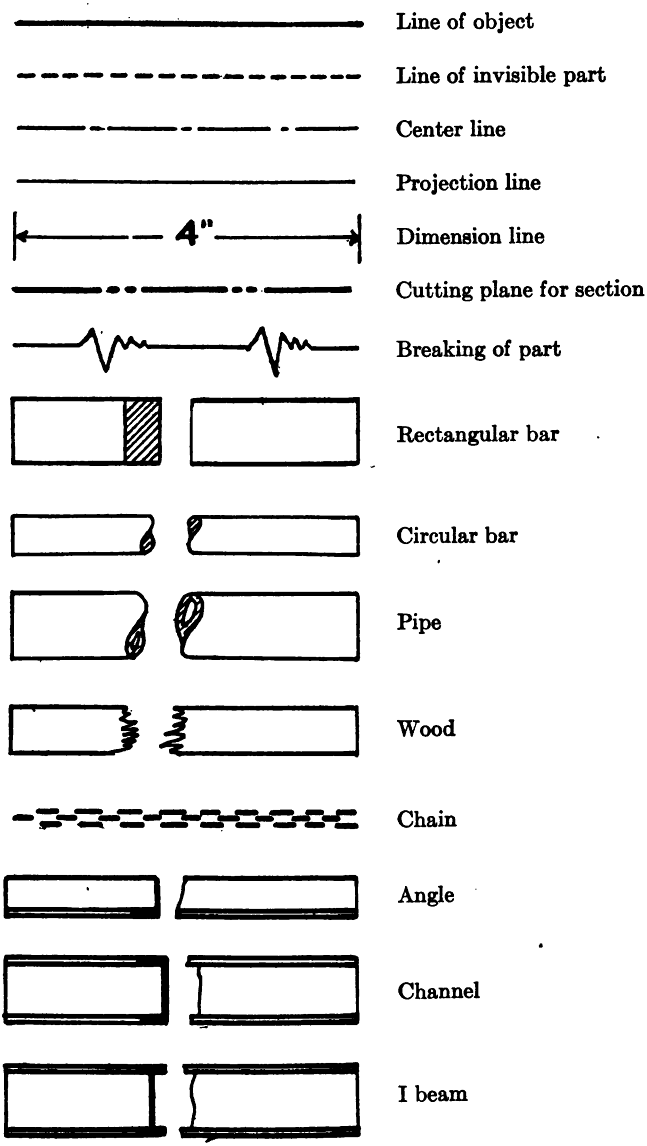
Common Abbreviations

″ or ins.	= inches	□″ or sq. ins.	= square inches
′ or ft.	= feet	□′ or sq. ft.	= square feet
f.	= surface to be finished	F.A.O.	= finished all over
C.L.	= center line	dia.	= diameter
Cb.	= counterbore	thds.	= threads
Csk.	= countersunk	U.S.G.	= United States Gauge
B.W.G.	= Birmingham or Stubs Wire Gauge		
B. & S.	= Brown & Sharpe or American Standard Wire Gauge		
A.W.G.	= American Wire Gauge	c.i.	= cast iron
w.i.	= wrought iron	m.i.	= malleable iron
c.s.	= cast steel	Br.	= brass
Bz.	= bronze	O.d.	= outside dia. I.d. = inside dia.
Zn.	= zinc	# or lb.	= pound
Ft.B.M.	= feet board measure	° or deg.	= degree
π	= 3.14159	C. to C.	= center to center

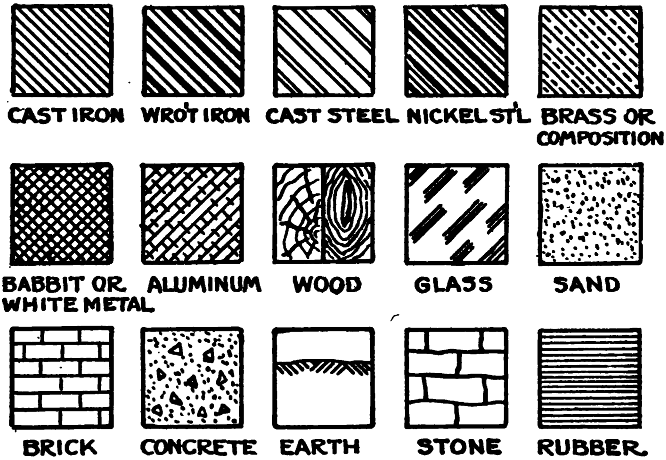
Dimensions not to scale should be underscored or marked "Not to Scale."

Where several pieces are shown on a drawing always have a bill of material and a table for noting alterations and date.

The title is preferably printed in the lower right hand corner.


Line of object
Line of invisible part
Center line
Projection line
4"
Dimension line
Cutting plane for section
Breaking of part
Rectangular bar
Circular bar
Pipe
Wood
Chain
Angle
Channel
I beam

Hatchings for Sections



Rivet Markings, see page 275.

LIMIT STANDARDS

Explanation

Symbols used on drawing—Using 1″ as an example

1″ **Rough gauge.**—Shaft to be ground and to use gauge for shaft work preparatory to grinding.

1″ **Finish gauge.**—Shaft to be turned or ground to gauge furnished and within the "Go" and "No Go" limits.

1″ **Drive gauge.**—Shaft to be turned or ground for a drive fit, and to be furnished to limits of "Go" and "No Go" gauge.

1″ **Free hole** (Free holes taking in running and sliding fits).—Hole to be bored or reamed to plug furnished and to come within "Go" and "No Go" limits.

1″ **Standard plug.**—Hole to be bored or reamed to standard plug furnished and to come within limits of "Go" and "No Go" gauges.

SYMBOL—FINISH GAUGE STANDARD SHAFT USE WITH STANDARD HOLE (WRINGING FIT) USE WITH FREE HOLE (RUNNING FIT)			DIA. IN INCHES
Maximum	Minimum	Tolerance	
.3750	.3743	.0007	3/8
.4375	.4368	.0007	7/16
.5000	.4990	.0010	1/2
.5625	.5615	.0010	9/16
.6250	.6240	.0010	5/8
.6875	.6865	.0010	11/16
.7500	.7490	.0010	3/4
.8125	.8115	.0010	13/16
.8750	.8740	.0010	7/8
.9375	.9365	.0010	15/16
1.0000	.9990	.0010	1
1.0625	1.0615	.0010	1 1/16
1.1250	1.1240	.0010	1 1/8
1.1875	1.1865	.0010	1 3/16
1.2500	1.2490	.0010	1 1/4
1.3125	1.3115	.0010	1 5/16
1.3750	1.3740	.0010	1 3/8
1.4375	1.4365	.0010	1 7/16
1.5000	1.4990	.0010	1 1/2
1.5625	1.5615	.0010	1 9/16
1.6250	1.6240	.0010	1 5/8
1.6875	1.6865	.0010	1 11/16
1.7500	1.7490	.0010	1 3/4
1.8125	1.8115	.0010	1 13/16
1.8750	1.8740	.0010	1 7/8
1.9375	1.9365	.0010	1 15/16
2.0000	1.9990	.0010	2
2.1250	2.1240	.0010	2 1/8
2.2500	2.2490	.0010	2 1/4
2.3750	2.3740	.0010	2 3/8
2.5000	2.4990	.0010	2 1/2
2.6250	2.6240	.0010	2 5/8
2.7500	2.7490	.0010	2 3/4
2.8750	2.8740	.0010	2 7/8
3.0000	2.9985	.0015	3
3.1250	3.1235	.0015	3 1/8
3.2500	3.2485	.0015	3 1/4
3.3750	3.3735	.0015	3 3/8
3.5000	3.4985	.0015	3 1/2
3.6250	3.6235	.0015	3 5/8
3.7500	3.7485	.0015	3 3/4
3.8750	3.8735	.0015	3 7/8
4.0000	3.9985	.0015	4
4.1250	4.1235	.0015	4 1/8
4.2500	4.2485	.0015	4 1/4
4.3750	4.3735	.0015	4 3/8
4.5000	4.4985	.0015	4 1/2
4.6250	4.6235	.0015	4 5/8
4.7500	4.7485	.0015	4 3/4
4.8750	4.8735	.0015	4 7/8
5.0000	4.9985	.0015	5
5.1250	5.1235	.0015	5 1/8
5.2500	5.2485	.0015	5 1/4
5.3750	5.3735	.0015	5 3/8
5.5000	5.4985	.0015	5 1/2
5.6250	5.6235	.0015	5 5/8
5.7500	5.7485	.0015	5 3/4
5.8750	5.8735	.0015	5 7/8
6.0000	5.9980	.002	6
6.1250	6.1230	.002	6 1/8
6.2500	6.2480	.002	6 1/4
6.3750	6.3730	.002	6 3/8

SYMBOL—ROUGH GAUGE ROUGH TURNING PREPARATORY to GRINDING (Special Cases on Long Shafts) SCREW MACHINE WORK			DIA. IN INCHES
Maximum	Minimum	Tolerance	
.387	.383	.004	3/8
.449	.445	.004	7/16
.512	.508	.004	1/2
.575	.570	.005	9/16
.638	.633	.005	5/8
.701	.695	.006	11/16
.765	.759	.006	3/4
.827	.821	.006	13/16
.890	.884	.006	7/8
.952	.946	.006	15/16
1.016	1.010	.006	1
1.078	1.072	.006	1 1/16
1.141	1.135	.006	1 1/8
1.203	1.197	.006	1 3/16
1.268	1.262	.006	1 1/4
1.330	1.324	.006	1 5/16
1.393	1.387	.006	1 3/8
1.455	1.449	.006	1 7/16
1.518	1.512	.006	1 1/2
1.580	1.574	.006	1 9/16
1.643	1.637	.006	1 5/8
1.705	1.699	.006	1 11/16
1.771	1.765	006	1 3/4
1.833	1.827	006	1 13/16
1.896	1.890	006	1 7/8
1.958	1.952	.006	1 15/16
2.028	2.020	008	2
2.153	2.145	.008	2 1/8
2.278	2.270	.008	2 1/4
2.403	2.395	008	2 3/8
2.528	2.520	.008	2 1/2
2.653	2.645	.008	2 5/8
2.778	2.770	.008	2 3/4
2.903	2.895	.008	2 7/8
3.035	3.025	.010	3
3.160	3.150	.010	3 1/8
3.285	3.275	.010	3 1/4
3.410	3.400	.010	3 3/8
3.535	3.525	.010	3 1/2
3.660	3.650	.010	3 5/8
3.785	3.775	.010	3 3/4
3.910	3.900	.010	3 7/8
4.035	4.025	.010	4

SYMBOL—STANDARD PLUG WRINGING AND DRIVE FITS STANDARD HOLE WRINGING FIT, USE WITH ST'D SHAFT DRIVE FIT, USE WITH DRIVE FIT SHAFT			DIA. IN INCHES	SYMBOL—FREE HOLE RUNNING AND SLIDING FITS FREE HOLE USE WITH STANDARD SHAFT		
Maximum	Minimum	Tolerance		Maximum	Minimum	Tolerance
.3750	.3747	.0003	3/8	.3760	.3755	.0005
.4375	.4372	.0003	7/16	.4385	.4380	.0005
.5000	.4995	.0005	1/2	.5015	.5008	.0007
.5625	.5620	.0005	9/16	.5640	.5633	.0007
.6250	.6245	.0005	5/8	.6265	.6258	.0007
.6875	.6870	.0005	11/16	.6890	.6883	.0007
.7500	.7495	.0005	3/4	.7515	.7508	.0007
.8125	.8120	.0005	13/16	.8140	.8133	.0007
.8750	.8745	.0005	7/8	.8765	.8758	.0007
.9375	.9370	.0005	15/16	.9390	.9383	.0007
1.0000	.9993	.0007	1	1.0020	1.0010	.0010
1.0625	1.0618	.0007	1 1/16	1.0645	1.0635	.0010
1.1250	1.1243	.0007	1 1/8	1.1270	1.1260	.0010
1.1875	1.1868	.0007	1 3/16	1.1895	1.1885	.0010
1.2500	1.2493	.0007	1 1/4	1.2520	1.2510	.0010
1.3125	1.3118	.0007	1 5/16	1.3145	1.3135	.0010
1.3750	1.3743	.0007	1 3/8	1.3770	1.3760	.0010
1.4375	1.4368	.0007	1 7/16	1.4395	1.4385	.0010
1.5000	1.4993	.0007	1 1/2	1.5025	1.5012	.0013
1.5625	1.5618	.0007	1 9/16	1.5650	1.5637	.0013
1.6250	1.6243	.0007	1 5/8	1.6275	1.6262	.0013
1.6875	1.6868	.0007	1 11/16	1.6900	1.6887	.0013
1.7500	1.7493	.0007	1 3/4	1.7525	1.7512	.0013
1.8125	1.8118	.0007	1 13/16	1.8150	1.8137	.0013
1.8750	1.8743	.0007	1 7/8	1.8775	1.8762	.0013
1.9375	1.9368	.0007	1 15/16	1.9400	1.9387	.0013
2.0000	1.9990	.0010	2	2.0030	2.0015	.0015
2.1250	2.1240	.0010	2 1/8	2.1280	2.1265	.0015
2.2500	2.2490	.0010	2 1/4	2.2530	2.2515	.0015
2.3750	2.3740	.0010	2 3/8	2.3780	2.3765	.0015
2.5000	2.4990	.0010	2 1/2	2.5030	2.5015	.0015
2.6250	2.6240	.0010	2 5/8	2.6280	2.6265	.0015
2.7500	2.7490	.0010	2 3/4	2.7530	2.7515	.0015
2.8750	2.8740	.0010	2 7/8	2.8780	2.8765	.0015
3.0000	2.9990	.0010	3	3.0035	3.0020	.0015
3.1250	3.1240	.0010	3 1/8	3.1285	3.1270	.0015
3.2500	3.2490	.0010	3 1/4	3.2535	3.2520	.0015
3.3750	3.3740	.0010	3 3/8	3.3785	3.3770	.0015
3.5000	3.4990	.0010	3 1/2	3.5035	3.5020	.0015
3.6250	3.6240	.0010	3 5/8	3.6285	3.6270	.0015
3.7500	3.7490	.0010	3 3/4	3.7535	3.7520	.0015
3.8750	3.8740	.0010	3 7/8	3.8785	3.8770	.0015
4.0000	3.9990	.0010	4	4.0035	4.0020	.0015
			4 1/8	4.1290	4.1270	.002
4.2500	4.2485	.0015	4 1/4	4.2540	4.2520	.002
			4 3/8	4.3390	4.3370	.002
			4 1/2	4.5045	4.5025	.002
			4 5/8	4.6295	4.6275	.002
			4 3/4	4.7545	4.7525	.002

Continued from page 6

SYMBOL—STANDARD PLUG WRINGING AND DRIVE FITS STANDARD HOLE WRINGING FIT, USE WITH STANDARD SHAFT DRIVE FIT, USE WITH DRIVE FIT SHAFT			DIA. IN INCHES	SYMBOL—FREE HOLE RUNNING AND SLIDING FITS FREE HOLE USE WITH STANDARD SHAFT		
Maximum	Minimum	Tolerance		Maximum	Minimum	Tolerance
			4⅞	4.8795	4.8775	.002
			5	5.0050	5.0030	.002
			5⅛	5.1300	5.1280	.002
			5¼	5.2550	5.2530	.002
			5⅜	5.3800	5.3780	.002
			5½	5.5055	5.5035	.002
			5⅝	5.6305	5.6285	.002
			5¾	5.7555	5.7535	.002
			5⅞	5.8805	5.8785	.002
			6	6.0070	6.0040	.003
			6⅛	6.1320	6.1290	.003
			6¼	6.2570	6.2540	.003
			6⅜	6.3820	6.3790	.003
			6½	6.5075	6.5045	.003
			6⅝	6.6325	6.6295	.003
			6¾	6.7575	6.7545	.003
			6⅞	6.8825	6.8795	.003
			7	7.0080	7.0050	.003

PRESS AND SHRINK FITS

Press fits.—Either one or both parts are given a slight taper as 1/16 to 5/32 in. per foot. The allowance between a hole in a cast iron hub and a steel shaft to be pressed in, may be taken as about .004 in., and for a steel hub and shaft .003. Press fits are not as satisfactory as shrink for resisting torsional stresses.

Shrink fits.—Both hole and shaft are generally cylindrical altho sometimes a slight taper is given. For cast iron and steel shrink fits an allowance of .0015 times the diameter of the shaft plus .005 in. may be used. Some companies make no difference in allowance between press and shrink fits.

SYMBOL—BEARING PLUG BRONZE BEARING LIMIT STANDARD				STANDARD SHAFT BEARING PLUG ALLOWANCE FOR RUNNING FIT	
Size	Maximum	Minimum	Tolerance	Maximum	Minimum
5/8	.6273	.6258	.0015	.0033	.0008
11/16	.6898	.6883	.0015	.0033	.0008
3/4	.7523	.7508	.0015	.0033	.0008
13/16	.8148	.8133	.0015	.0033	.0008
7/8	.8773	.8758	.0015	.0033	.0008
15/16	.9398	.9383	.0015	.0033	.0008
1	1.0030	1.0010	.002	.0040	.0010
1 1/16	1.0655	1.0635	.002	.0040	.0010
1 1/8	1.1280	1.1260	.002	.0040	.0010
1 3/16	1.1905	1.1885	.002	.0040	.0010
1 1/4	1.2530	1.2510	.002	.0040	.0010
1 5/16	1.3155	1.3135	.002	.0040	.0010
1 3/8	1.3780	1.3760	.002	.0040	.0010
1 7/16	1.4410	1.4385	.0025	.0045	.0010
1 1/2	1.5037	1.5012	.0025	.0047	.0012
1 9/16	1.5662	1.5637	.0025	.0047	.0012
1 5/8	1.6287	1.6262	.0025	.0047	.0012
1 11/16	1.6912	1.6887	.0025	.0047	.0012
1 3/4	1.7537	1.7512	.0025	.0047	.0012
1 13/16	1.8162	1.8137	.0025	.0047	.0012
1 7/8	1.8787	1.8762	.0025	.0047	.0012
1 15/16	1.9412	1.9387	.0025	.0047	.0012
2	2.0045	2.0015	.003	.0055	.0015
2 1/8	2.1295	2.1265	.003	.0055	.0015
2 1/4	2.2545	2.2515	.003	.0055	.0015
2 3/8	2.3795	2.3765	.003	.0055	.0015
2 1/2	2.5045	2.5015	.003	.0055	.0015
2 5/8	2.6295	2.6265	.003	.0055	.0015
2 3/4	2.7545	2.7515	.003	.0055	.0015
2 7/8	2.8795	2.8765	.003	.0055	.0015
3	3.0050	3.0020	.003	.0065	.0020
3 1/8	3.1300	3.1270	.003	.0065	.0020
3 1/4	3.2550	3.2520	.003	.0065	.0020
3 3/8	3.3800	3.3770	.003	.0065	.0020
3 1/2	3.5050	3.5020	.003	.0065	.0020
3 5/8	3.6300	3.6270	.003	.0065	.0020
3 3/4	3.7550	3.7520	.003	.0065	.0020
3 7/8	3.8800	3.8770	.003	.0065	.0020
4	4.0055	4.0020	.0035	.0070	.0020
4 1/8	4.1305	4.1270	.0035	.0070	.0020

LIMIT OF WEAR ON PLUG GAUGES

Standard Plugs	Free Hole, Roughing and Special Plugs
Tolerance of .0003 to .0005—.0002	Tolerance of .0005 to .001—.0003
" " .0005 " .0015—.0003	" " .001 " .005—.0005
	" " over .005—.001

U. S. PATENT OFFICE DRAWINGS

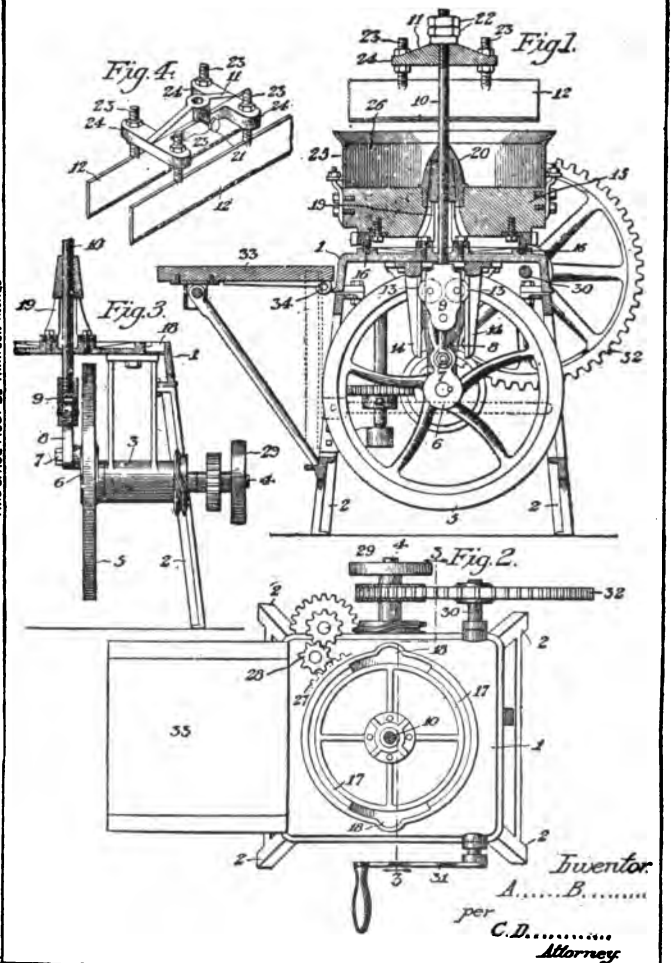
Drawings must be made upon pure white paper of a thickness corresponding to two-sheet or three-sheet Bristol board. The surface of the paper must be calendered and smooth. India ink alone must be used, to secure perfectly black and solid lines.

The size of a sheet on which a drawing is made must be exactly 10 by 15 ins. One inch from its edges a single marginal line is to be drawn, leaving the "sight" precisely 8 by 13 ins. Within this margin all work and signatures must be included. One of the shorter sides of the sheet is regarded as its top, and, measuring downward from the marginal line, a space of not less than 1¼ ins. is to be left blank for the heading of title, name, number and date.

All drawings must be made with the pen only. Every line and letter (signatures included) must be absolutely black. This direction applies to all lines, however fine, to shading, and to lines representing cut surfaces in sectional views. All lines must be clean, sharp and solid, and they must not be too fine or crowded. Surface shading, when used, should be open. Sectional shading should be made by oblique parallel lines, which may be about one-twentieth of an inch apart. Solid black should not be used for sectional or surface shading. Free-hand work should be avoided wherever it is possible to do so.

Drawings should be made with the fewest lines possible consistent with clearness. Shading (except on sectional views) should be used only on convex and concave surfaces, where it should be used sparingly, and may even there be dispensed with if the drawing be otherwise well executed. The plane upon which a sectional view is taken should be indicated on the general view by a broken or dotted line, which should be designated by numerals corresponding to the number of the sectional view. Heavy lines on the shade sides of objects should be used, except where they tend to thicken the work and obscure letters of reference. The light is always sup-

THE SIZE OF THE SHEET MUST BE EXACTLY
10 x 15 INCHES.



THIS SPACE MUST BE THIRTEEN INCHES

THIS SPACE MUST BE EIGHT INCHES

posed to come from the upper left hand corner at an angle of 45 degs.

The scale to which a drawing is made ought to be large enough to show the mechanism without crowding, and two or more sheets should be used if one does not give sufficient room to accomplish this end; but the number of sheets must never be more than is absolutely necessary.

The different views should be consecutively numbered. Letters and figures of reference must be carefully formed. They should, if possible, measure at least one-eighth of an inch in height, so that they may bear reducing to one twenty-fourth of an inch; and they may be much larger when there is sufficient room. They must be so placed in the close and complex parts of drawings as not to interfere with a thorough comprehension of the same, and therefore should rarely cross or mingle with the lines. When necessarily grouped around a certain part they should be placed at a little distance, where there is available space, and connected by lines with the parts to which they refer. They should not be placed upon shaded surfaces, but when it is difficult to avoid this, a blank space must be left in the shading where the letter occurs, so that it shall appear perfectly distinct and separate from the work. If the same part of an invention appear in more than one view of the drawing it must always be represented by the same character, and the same character must never be used to designate different parts.

The signature of the applicant should be placed at the lower right hand corner of each sheet, and the signatures of the witnesses, if any, at the lower left hand corner, all within the marginal line, but in no instance should they trespass upon the drawings. The title should be written with pencil on the back of the sheet. The permanent names and title constituting the heading will be applied subsequently by the office in uniform style.

All views on the same sheet must stand in the same direction and must if possible stand so that they can be read with the sheet held in an upright position. If views longer than the width of the sheet are necessary for the proper illustration of the invention the sheet may be turned on its side. The space for heading must then be reserved at the right and the signatures placed at the left, occupying the same space and position as in the upright views and being horizontal when the sheet is held in an upright position. One figure must not be placed upon another or within the outline of another.

Drawings transmitted to the U. S. Patent Office should be sent flat, protected by a sheet of heavy binder's board; or should be rolled for transmission in a suitable mailing tube, but should never be folded.

An agent's or attorney's stamp, or advertisement or written address will not be permitted upon the face of a drawing, within or without the marginal line.

Weight of Wood Patterns Compared to Weight of Castings

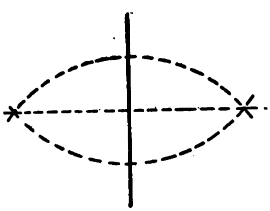
A pattern weighing one pound (less weight of core boxes) made of	Cast Iron Lbs.	Brass Lbs.	Bronze Lbs.	Copper Lbs.	Zinc Lbs.
Pine or fir	16.	18.8	19.3	19.7	15.5
Mahogany	11.7	13.2	13.5	13.7	11.2
Brass	.85	.95	.98	.99	.81
Pear	10.2	11.5	11.8	11.9	9.8

Thus if a pine pattern weighed one pound, a casting of cast iron from it would weigh 16 lbs., of brass 18.8 lbs., of bronze 19.3 lbs., etc.

Shrinkage of Castings

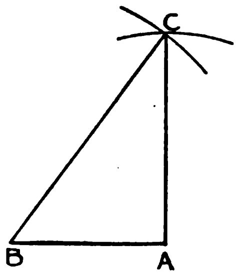
Patterns for castings should be made larger than dimensions given on drawings to allow for shrinkage. For iron castings (gray and malleable) the allowance for shrinkage is $\frac{1}{8}$ inch per foot, for steel $\frac{1}{4}$ inch, for brass $\frac{3}{16}$ inch, for lead $\frac{1}{8}$ inch, for tin $\frac{1}{12}$ inch and for zinc $\frac{3}{16}$ inch.

GEOMETRICAL CONSTRUCTIONS

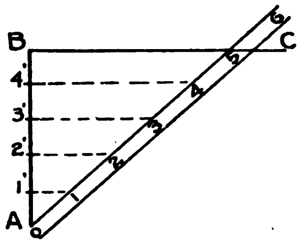


To Bisect a Straight Line and Draw a Perpendicular to It.—With the ends as centers and with a radius greater than one-half the line, describe arcs intersecting on both sides of the line. A line through the intersections will bisect the line and be perpendicular to it.

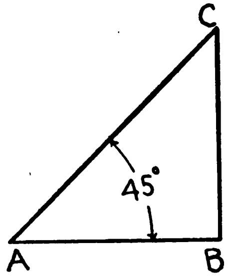
To Draw a Right Triangle, Given One Side.—Let A B be the side, and divide it into 6 equal parts. With A as center and radius equal to 8 parts describe an arc. With B as center and radius equal to 10 parts describe another arc. From their intersection C draw A C and C B, A C being perpendicular to A B.

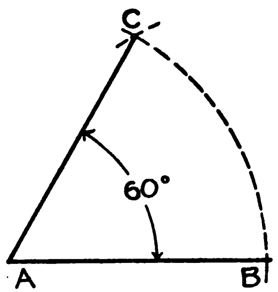


To Divide a Line Into a Number of Equal Parts when the divisions on the scale are larger than the parts. If A B is the line, draw B C perpendicular to it. Suppose A B is to be divided into 5 equal parts—take a scale or a foot rule and place one end at A and the division 5 of the scale on the line B C. Draw horizontal lines through the divisions 1, 2, 3 and 4,—then their intersections on A B as 1′, 2′, 3′ and 4′ are equal parts of the line A B.



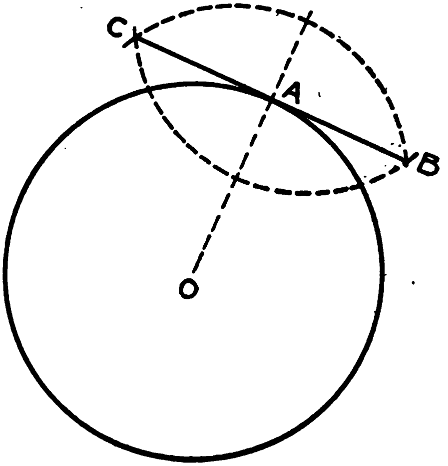
To Lay Off a 45 Deg. Angle.—Let A B and B C be two equal lines forming a right angle. A line connecting A and C will be at an angle of 45 degs. to A B.



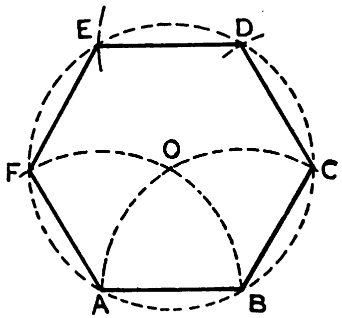


To Lay Off a 60 Deg. Angle.—From the line A B, with A as center, and any radius draw arc B C. With the same radius and B as center describe an arc cutting B C at C. Join A and C. The line A C will make an angle of 60 degs. with A B. For an angle of 30 degs. bisect B C.

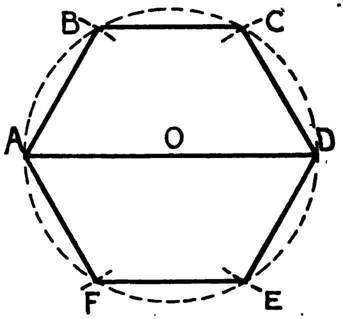
To Draw a Tangent to a Circle From a Point on the Circumference.—If A is the point, draw a radial line O A. At A draw a line B C at right angles to O A, which line will be tangent to the circumference at A.



To Draw a Hexagon When the Length of One Side is Given.—Let A B be the given side, then with A B as a radius and A and B as centers draw arcs intersecting at O. With O as center and radius A B draw a circle through A and B. With the same radius and C as center describe an arc cutting the circle at D. Points E and F are obtained in a similar way. Connecting B, C, D, E, F and A gives the required hexagon.



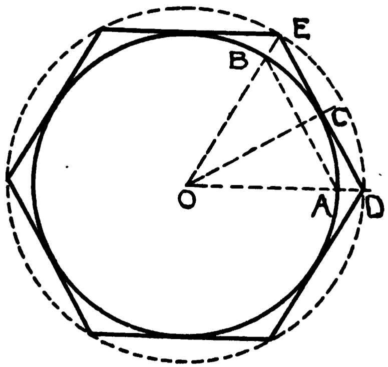
To Draw a Hexagon, Given the Long Diameter.—Bisect the long diameter A D at O. With O as center and A O as radius describe a circle. Using the same radius and A as center, draw an arc cut-



ting the circle at B and F. With D as center describe an arc cutting the circle at C and E. Connect A, B, C, D, E and F.

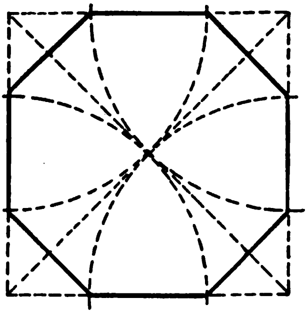
To Inscribe a Hexagon in a Circle.—Divide the circle into six parts by stepping around the circumference with dividers a chord equal to the radius. Draw lines connecting the consecutive points.

To Circumscribe a Hexagon About a Circle.—Lay off a chord A B equal to the radius of the circle, and bisect its arc at C. At C draw a tangent D E meeting O D and O E. Describe a circle with radius O D, and space O D around the circle—the points thus obtained when joined will form a hexagon.



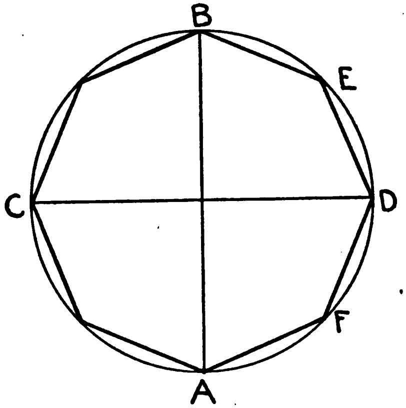
Or draw a line O D. Lay a 60 deg. triangle on O D so that it is tangent to the circle at C. The tangent drawn will be one side of the hexagon. At E, draw a horizontal line tangent to the given circle. By the continued use of the 60 deg. triangle the other sides of the hexagon can be drawn.

To Inscribe an Octagon in a Square.—Draw the diagonals of the square. With the corners as centers and a radius of one-half a

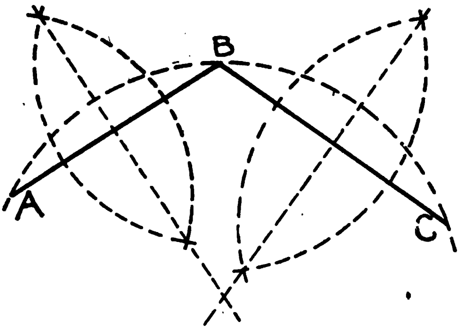


diagonal draw arcs cutting the sides of the square. Connect the intersections of the arcs and the sides of the square.

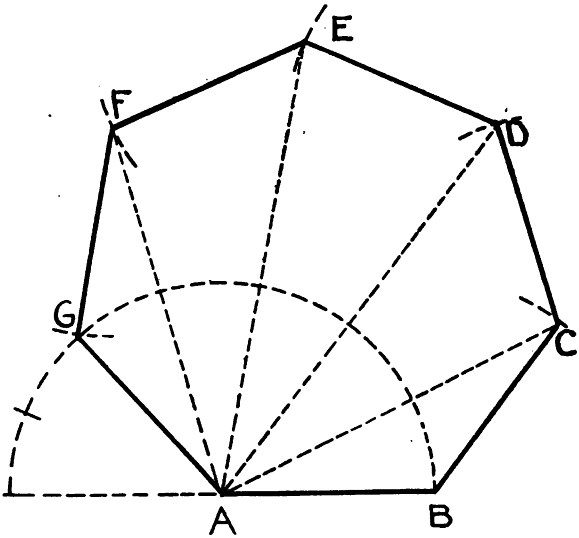
To Inscribe an Octagon in a Circle.—Draw A B perpendicular to C D. Bisect the arc B D at E, A D at F, etc. Join points B, E, D, F, etc.



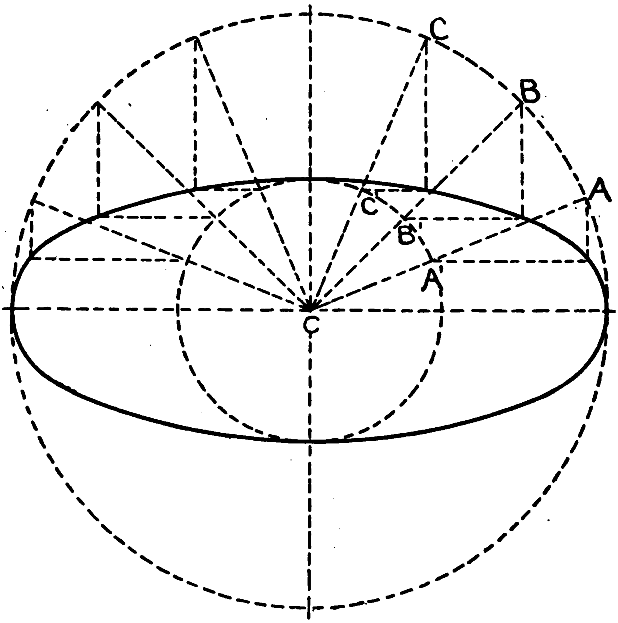
To Draw an Arc Through Three Points A, B and C.—Join the points. Bisect A B and B C, and at their centers draw perpendiculars. Where the perpendiculars meet is the center of the required arc.



To Construct a Polygon of n Sides Having Given One Side A B.—With A B as radius and A as center describe a semicircle and divide

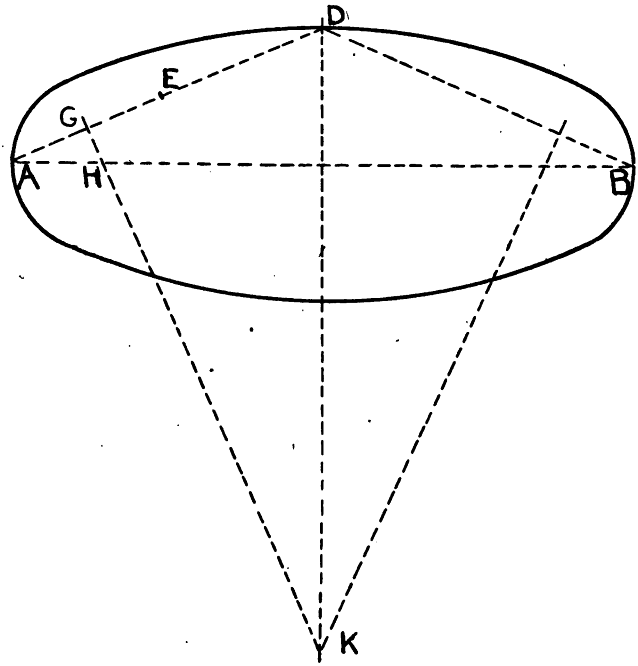


it into n parts. From n subtract 2, the remainder being the number of parts through which lines G A, A F, etc. are drawn. In the present case n = 7, and there are thus 5 parts from B to G. With A B as radius and B as center describe an arc cutting A C at C,—with the same radius and C as center describe an arc cutting A D, and so on, giving points E, F and G. By connecting the points a polygon is formed.



To Draw an Ellipse.—*First Method.*—With C as a center draw two circles, one with the diameter equal to the major axis of the ellipse and the other equal to the minor axis. Divide the circumference of the large circle into any number of equal parts and draw from the divisions lines to the center C. Draw vertical lines from A, B, C, etc., and horizontal from A′, B′, C′, etc. The intersections of the vertical and horizontal lines will be points on the ellipse.

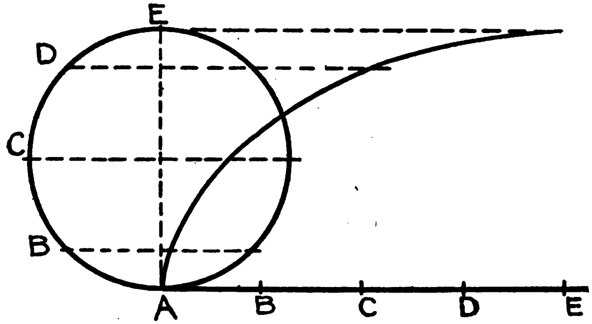
Second Method.—Lay off D E equal to the difference between the major and minor axes of the required ellipse. Bisect A E and erect a perpendicular to A D at G, cutting A B at H and D K at K. Follow the same procedure on B D. Then H and K are cen-



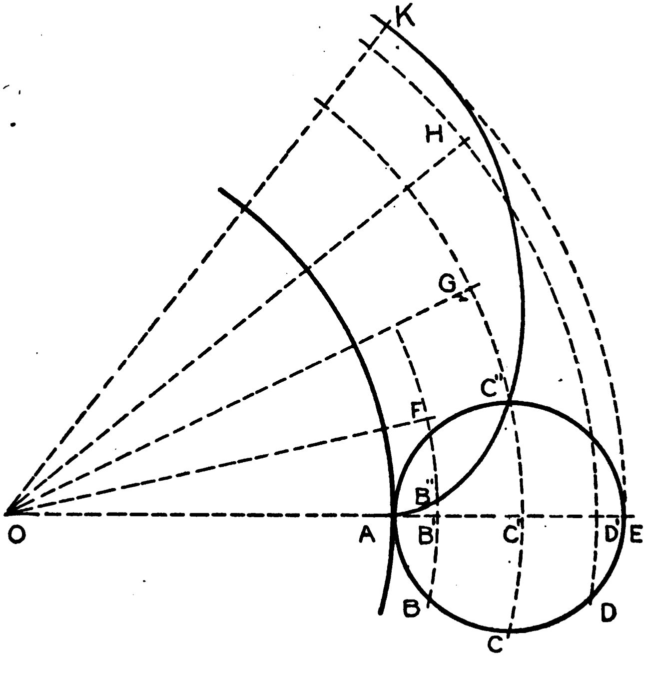
ters for two arcs approximately forming part of an ellipse—the centers for the other two arcs are found in a similar manner to that just outlined.

Cycloid.—This curve is traced by a point on the circumference of a circle rolling on a straight line without slipping. If A E is the diameter of the generating circle, divide the semi-circumference into n equal parts, and lay off the arcs A B, A C, etc., along the base

line A E. On horizontal lines through B, C, etc., lay off A B, A C, etc. A curve through the ends of these lines will be a cycloid.

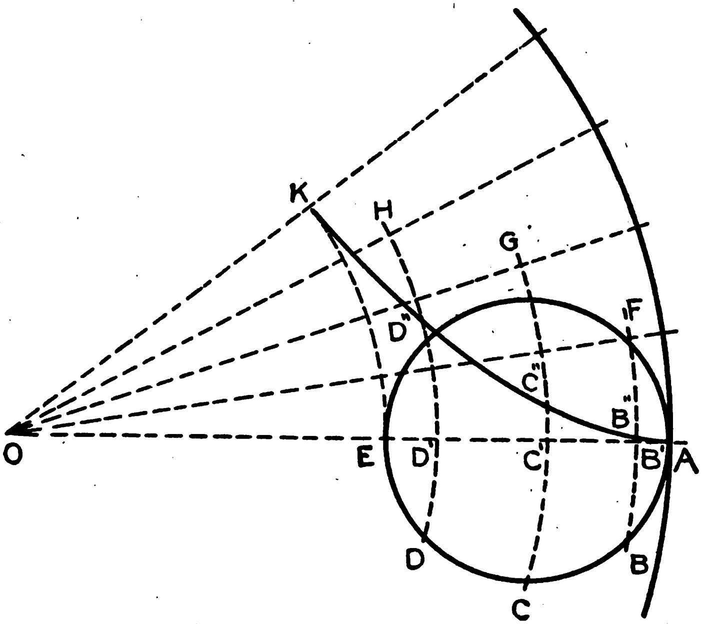


Epicycloid.—A curve generated by a point on the circumference of a circle which rolls without slipping on the outside of another



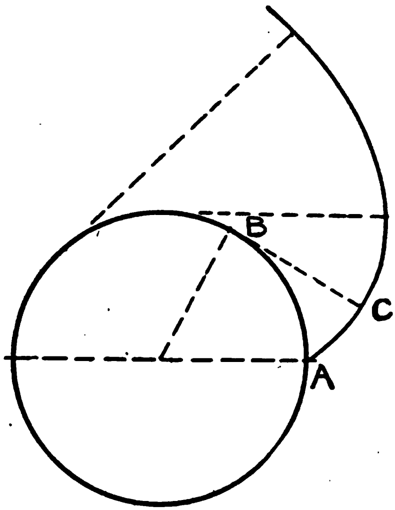
circle—is an epicycloid. Divide the semi-circumference of the rolling circle into n equal parts (in the present case into 4) and lay off the arcs A B, A C, A D and A E on the circumference of the base circle. With O as center draw arcs through B, C, D, E cutting the extended radii of the base circle at F, G, H, K. From F, G, H lay off arcs equal to B B′, C C′, D D′. A curve passing through B″, C″, etc., is an epicycloid.

Hypocycloid.—This curve is generated by a point on the circumference of a circle which rolls without slipping on the inside of



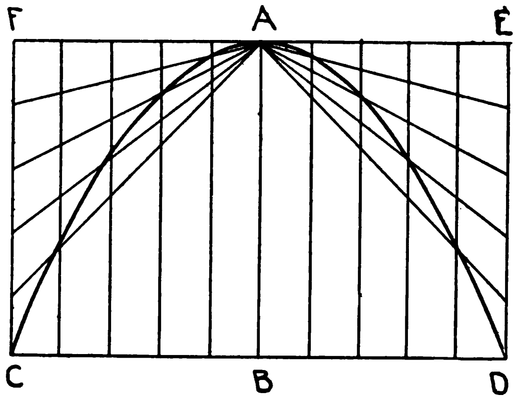
another circle. Divide the semi-circumference of the rolling circle into n equal parts (in the present case into 4) and lay off the arcs A B, A C, A D on the circumference of the base circle. With O as center draw arcs through B, C, D, E cutting the radii of the base circle at F, G, H, K. From F, G, H lay off arcs equal to B B′, C C′, D D′. A curve passing through B″, C″, etc. is a hypocycloid.

Involute.—A curve traced by the end of a taut string unwound from the circumference of a circle is an involute. If B C is tangent



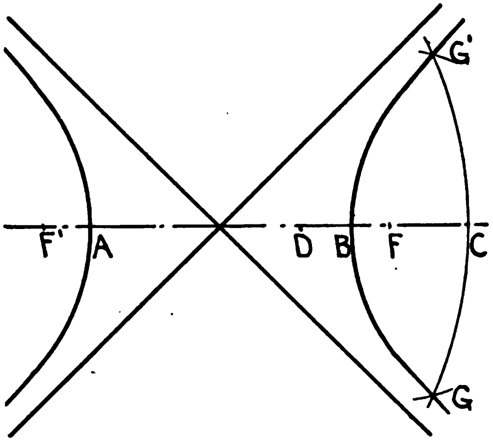
to the circle, lay off on it, the arc A B—then the point C is on the involute. By drawing more tangents other points can be found.

Parabola.—Height A B and base C D given. Divide C D into



any number of even parts as 10, and erect perpendiculars. Divide the sides C F and D E into the same number of parts as C B and B D. From the divisions on C F and D E draw lines to the apex A. Where these lines cut the perpendiculars from C D are points in the parabola.

Hyperbola.—Let A B be the distance between the two branches of the hyperbola, and F and F′ the foci. Take any distance as F′ C and with F′ as center describe an arc. Lay off F′ D = A B.



With F as center and radius D C describe an arc cutting the previous one at G and G′, which are points on the hyperbola. Other points can be found in a similar way.

Laying Off Angles with a Two-Foot Rule

To lay off an angle, open the ends of the rule to the distance given in the following table. Thus for a 45 deg. angle open the rule until the ends are 9.20 ins. apart.

Degrees	Inches	Degrees	Inches	Degrees	Inches
1	.21	15	3.12	55	11.08
2	.422	20	4.17	60	12
3	.633	25	5.21	65	12.89
4	.837	30	6.21	70	13.76
5	1.04	35	7.20	75	14.61
7.5	1.57	40	8.21	80	15.43
10	2.09	45	9.20	85	16.21
14.5	3.015	50	10.12	90	16.97

TABLE FOR THE DIVISION OF THE CIRCUMFERENCE OF A CIRCLE

Number of Divisions in the Circumference	Angle of Corresponding Division of Circle; Degrees	Length of Chord in Decimal Fraction of Radius	Number of Divisions in the Circumference	Angle of Corresponding Division of Circle; Degrees	Length of Chord in Decimal Fraction of Radius
3	120	1.73206	52	6.55	0.120356
4	90	1.41422	53	6.47	0.118032
5	72	1.17558	54	6.40	0.11629
6	60	1	55	6.32	0.113966
7	51.25	0.86732	56	6.25	0.111644
8	45	0.76536	57	6.18	0.1099
9	40	0.68404	58	6.12	0.108158
10	36	0.61804	59	6.06	0.106414
11	32.43	0.563	60	6	0.104672
12	30	0.51764	61	5.54	0.102928
13	27	0.4782	62	5.48	0.101186
14	25	0.4448	63	5.42	0.99442
15	24	0.41582	64	5.37	0.0977
16	22.30	0.39018	65	5.32	0.096538
17	21.10	0.36734	66	5.27	0.094794
18	20	0.3473	67	5.22	0.093632
19	18.56	0.32894	68	5.17	0.091888
20	18	0.31286	69	5.13	0.090765
21	17.08	0.29792	70	5.08	0.089564
22	16.21	0.2841	71	5.04	0.088402
23	15.39	0.272	72	5	0.087238
24	15	0.26106	73	4.55	0.085496
25	14.24	0.25066	74	4.51	0.084332
26	13.50	0.24086	75	4.48	0.083752
27	13.20	0.23218	76	4.44	0.083588
28	12.51	0.22352	77	4.40	0.081426
29	12.24	0.216	78	4.36	0.080264
30	12	0.20906	79	4.33	0.0791
31	11.36	0.20212	80	4.30	0.078518
32	11.15	0.19574	81	4.20	0.077356
33	10.54	0.18996	82	4.23	0.076194
34	10.35	0.18416	83	4.20	0.075612
35	10.17	0.17894	84	4.17	0.07445
36	10	0.17432	85	4.14	0.073868
37	9.43	0.1691	86	4.11	0.072706
38	9.28	0.16504	87	4.08	0.072124
39	9.13	0.1604	88	4.05	0.070962
40	9	0.15692	89	4.02	0.07038
41	8.46	0.15286	90	4	0.069798
42	8.34	0.14938	91	3.57	0.0686362
43	8.22	0.1459	92	3.54	0.0680546
44	8.10	0.14242	93	3.52	0.0674732
45	8	0.13952	94	3.49	0.0663104
46	7.49	0.13603	95	3.47	0.0657288
47	7.39	0.133128	96	3.45	0.0651474
48	7.30	0.130806	97	3.42	0.064566
49	7.20	0.127904	98	3.40	0.0639844
50	7.12	0.125582	99	3.38	0.063403
51	7.03	0.122678	100	3.36	0.0628216

SECTION II

FASTENINGS

BOLTS—NUTS—SCREWS—THREADS FOR BOLTS, NUTS, SCREWS AND PIPE—TAP DRILLS—NAILS—SPIKES—KEYS—GIBS AND KEYS— T SLOTS—COTTERS

BOLTS

Measurement of Bolts, Screws and Rivets

The length of flat head screws, stove bolts and countersunk oval head screws includes the head and half the head of round head wood screws—but excludes the head of round and fillister head machine screws and round head stove bolts.

The length of rivets is exclusive of the head except countersunk heads, where the length of the head is included.

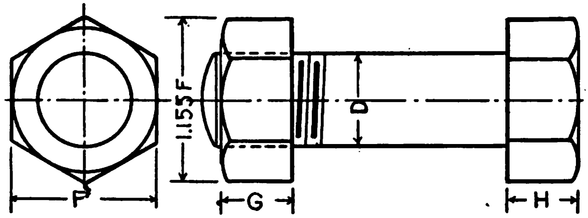
The diameter of screws is measured by the Brown and Sharpe gauge, see page 43.

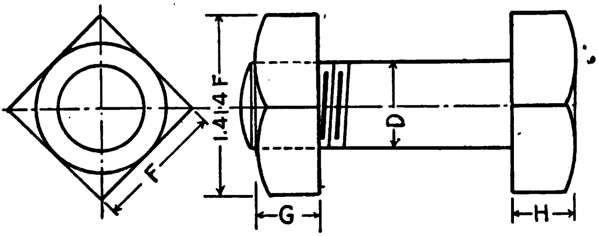
The diameter of structural rivets is given in inches or fractions thereof. See Structural Details, pages 270 and 271.

Materials

The material selected depends on the purpose the bolt is to be used for. The U. S. Navy for class B open hearth carbon steel requires a tensile strength of 58,000 lb. per sq. in., elastic limit 30,000 lb. per sq. in., elongation in 8 ins. of 289 and be bent cold 180 degs. without showing fracture. Special bolts as Society of Automotive Engineers hexagon head cap screws can be obtained with a tensile strength of 100,000 lb. per sq. in. and elastic limit of 60,000. Bolts, screws and nuts are also made of bronze and composition.

United States Standard Bolt Heads and Nuts





Finished Head		Finished Nut	
F	H	F	G
1.5 D + 1/16″	D — 1/16″	1.5 D + 1/16″	.5 F — 1/16″

Hexagon heads and nuts.—The distance between opposite corners (the long diameter) = 1.155 × the distance between sides (the short diameter).

Square heads and nuts.—The distance between opposite corners (the long diameter) = 1.414 × the diameter between sides (the short diameter).

Finished Hexagon Heads and Nuts

Dia. of bolt	Threads per in.	Diameter Short	Diameter Long	Height	Dia. of bolt	Threads per in.	Diameter Short	Diameter Long	Height
1/4	20	7/16	1/2	3/16	1 1/2	6	2 5/16	2 43/64	1 7/16
5/16	18	17/32	39/64	1/4	1 5/8	5 1/2	2 1/2	2 57/64	1 9/16
3/8	16	5/8	23/32	5/16	1 3/4	5	2 11/16	3 7/64	1 11/16
7/16	14	23/32	53/64	3/8	1 7/8	5	2 7/8	3 5/16	1 13/16
1/2	13	13/16	15/16	7/16	2	4 1/2	3 1/16	3 17/32	1 15/16
9/16	12	29/32	1 1/64	1/2	2 1/4	4 1/2	3 7/16	3 31/32	2 3/16
5/8	11	1	1 5/32	9/16	2 1/2	4	3 13/16	4 13/32	2 7/16
3/4	10	1 3/16	1 21/64	11/16	2 3/4	4	4 3/16	4 27/32	2 11/16
7/8	9	1 3/8	1 19/32	13/16	3	3 1/2	4 9/16	5 3/32	2 15/16
1	8	1 9/16	1 13/16	15/16	3 1/4	3 1/2	4 15/16	5 43/64	3 3/16
1 1/8	7	1 3/4	2 1/64	1 1/16	3 1/2	3 1/4	5 5/16	6 7/64	3 7/16
1 1/4	6	1 15/16	2 15/64	1 3/16	3 3/4	3	5 11/16	6 35/64	3 11/16
1 3/8	6	2 1/8	2 29/64	1 5/16	4	3	6 1/16	6 31/32	3 15/16

U. S. Standard is the same as the Franklin Institute. For working stress see U. S. Standard threads, page 59.

Manufacturers' Square and Hexagon Bolt Heads

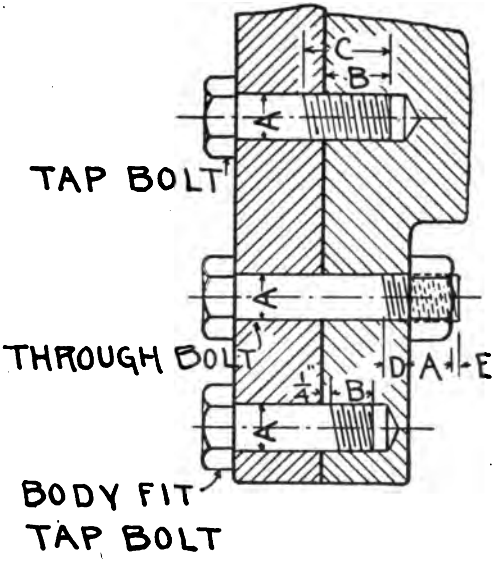
No universal standard has been adopted by all manufacturers. The following table gives dimensions commonly used:

Dia. of bolt	Short dia.	Height	Dia. of bolt	Short dia.	Height
1/4	3/8	3/16	3/4	1 1/8	9/16
5/16	15/32	15/64	7/8	1 5/16	21/32
3/8	9/16	9/32	1	1 1/2	3/4
7/16	21/32	21/64	1 1/8	1 11/16	27/32
1/2	3/4	3/8	1 1/4	1 7/8	15/16
9/16	27/32	27/64	1 3/8	2 1/16	1 1/32
5/8	15/16	15/32	1 1/2	2 1/4	1 1/8

[Russell, Burdsall & Ward Bolt & Nut Co., Port Chester, N. Y.]

For threads per inch see U. S. Standard Bolt Heads.

Screw Ends of Standard Hexagon-Headed Bolts



[Niles-Bement-Pond Co., New York, N. Y.]

A = diameter of bolt B = $1\frac{1}{2}$ A C = $1\frac{1}{2}$ A + $\frac{1}{4}$"

D = $\frac{1}{8}$" for bolts up to and including $\frac{5}{8}$" diameter and $\frac{1}{4}$" for those larger.

E = $\frac{1}{16}$" for bolts up to and including $\frac{7}{8}$" diameter and $\frac{1}{8}$" for those larger.

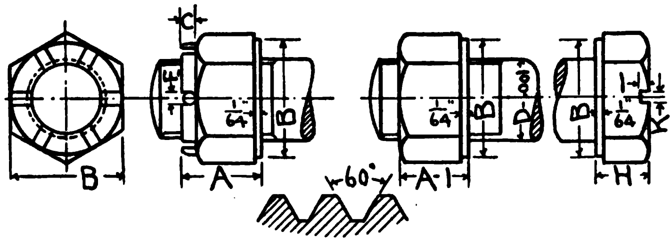
Height or thickness of nut is taken as equal to the diameter of the bolt, which is approximately true.

Studs in cast iron—depth of tap should be the same as for tap bolts, viz.: $1\frac{1}{2}$ times the diameter of the stud.

Drilled holes which are to be tapped should not extend into spaces subject to pressure.

Society of Automotive Engineers Bolts and Nuts

Castle Nut — Hexagon Bolt and Nut



S. A. E. Screw Thread

D = Diameter of Screw

P = Pitch of Thread

B = Short dia. of Nuts and Screw Heads

$\frac{1}{P}$ = Number of threads per in.

D x 1.5 + ¼ in. = Length of Threaded Portion

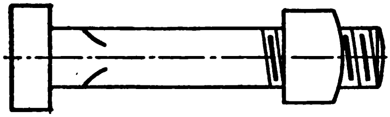
$\frac{P}{8}$ = Flat Top

d = Diameter of Cotter Pin

D.........	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	7/8	1
Thds per in.	28	24	24	20	20	18	18	16	16	14	14
A.........	9/32	21/64	13/32	29/64	9/16	39/64	23/32	49/64	13/16	29/32	1
A–1.......	7/32	17/64	21/64	3/8	7/16	31/64	35/64	19/32	21/32	49/64	7/8
B.........	7/16	1/2	9/16	5/8	3/4	7/8	15/16	1	1 1/16	1 1/4	1 7/16
C.........	3/32	3/32	1/8	1/8	3/16	3/16	1/4	1/4	1/4	1/4	1/4
E.........	5/64	5/64	1/8	1/8	1/8	5/32	5/32	5/32	5/32	5/32	5/32
H.........	3/16	15/64	9/32	21/64	3/8	27/64	15/32	33/64	9/16	21/32	3/4
I..........	3/32	7/64	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8
K.........	1/16	1/16	3/32	3/32	3/32	3/32	3/32	3/32	3/32	3/32	3/32
d.........	1/16	1/16	3/32	3/32	3/32	1/8	1/8	1/8	1/8	1/8	1/8
Tap drill..	7/32	17/64	21/64	3/8	7/16	1/2	9/16	39/64	43/64	25/32	29/32

Heads and nuts semi-finished.

DECK BOLTS



Round head, square under.

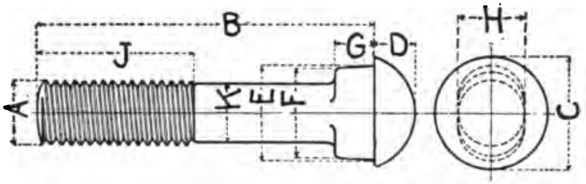
Length Over All in Inches	Diameter				
	3/8"	7/16"	1/2"	9/16"	5/8"
	lbs.*	lbs.*	lbs.*	lbs.*	lbs.*
1¾	9½	.....	.....	.....	.....
2	10½	16½	22	.....	.....
2¼	11½	17½	22½	.....	.....
2½	12½	18½	23	33½	40
2¾	13½	19½	24½	34	42
3	....	.....	26	34½	44
3½	....	.....	29	37½	48
4	....	.....	32	40½	52
4½	....	.....	35	44	56
Size of Head..	3/4 x 1/8	7/8 x 3/16	1 x 3/16	1 x 1/4	1 1/8 x 1/4
Size of Nut...	5/8 x 5/16	23/32 x 3/8	13/16 x 7/16	29/32 x 1/2	1 x 33/64
Thread per In.	16	14	13	12	11

[Hoopes & Townsend, Philadelphia, Pa.]

*Approximate weight per 100.

May be obtained black or galvanized.

Track Bolts



Track bolts are manufactured with U. S. Standard rolled thread, buttress and U. S. Standard cut thread. With rolled and buttress threads the diameter of the threaded portion is about 1/16 in. greater than the unthreaded, while with cut threads the diameter of the threaded and unthreaded portion is the same. Bolts may be obtained with either square or hexagon nuts.

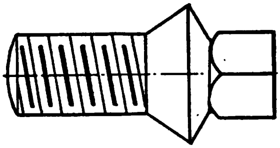
U. S. Standard Rolled Thread Track Bolt

Dia.	Length	Head		Shoulder				Length of thread	Dia. Shank	Nut	
A	B	C	D	E	F	G	H	J	K	Height	Width across flats
3/8	Per order	11/16	9/32	17/32	1/2	7/32	11/32	Per order	11/32	3/8	11/16
1/2		13/16	21/64	11/16	21/32	5/16	29/64		29/32	1/2	7/8
5/8		1 1/32	13/32	29/32	7/8	3/8	37/64		37/64	5/8	1 1/16
3/4		1 1/4	15/32	1 1/16	1 1/32	7/16	11/16		11/16	3/4	1 1/4
25/32		1 9/32	1/2	1 1/16	1 1/32	7/16	23/32		23/32	3/4	1 1/4
13/16		1 5/16	17/32	1 1/16	1 1/32	7/16	3/4		3/4	3/4	1 3/8
7/8		1 7/16	9/16	1 7/32	1 3/16	1/2	13/16		13/16	7/8	1 7/16
15/16		1 1/2	5/8	1 7/32	1 3/16	1/2	7/8		7/8	7/8	1 7/16
1		1 5/8	21/32	1 3/8	1 11/32	9/16	15/16		15/16	1	1 5/8
1 1/16		1 11/16	11/16	1 3/8	1 11/32	9/16	1		1	1	1 5/8

[Illinois Steel Co., Chicago, Ill.]

Bolts can be obtained with cut, rolled and rolled buttress threads.

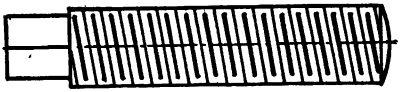
Boiler Patch Bolts or Tap Rivets



Diameter	½″	⅝″	¾″	⅞″	1″
Threads per inch	14	12	12	12	12
Length from largest diameter of bevel to point.	¾ ⅞ 1 1⅛ 1¼ 1½	¾ ⅞ 1 1⅛ 1¼ 1½	... ⅞ 1 1⅛ 1¼ 1½	... ... 1 1⅛ 1¼ 1½	. . 1 1⅛ 1¼ 1½

[Hoopes & Townsend, Philadelphia, Pa.]

Boiler Stay Bolts

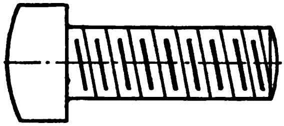


¾″, 13/16″, ⅞″, 15/16″, 1″, 1 1/16″, 1⅛″, 1 3/16″ and 1¼″ dia. All diameters have 12 threads per inch. Length of threaded part from 2½″ up,—cut to order. Stay bolts after being screwed into place may have nuts on the ends, instead of being riveted over.

[Hoopes & Townsend, Philadelphia, Pa.]

Tap Bolts

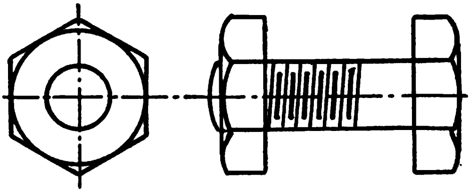
Square and Hexagon Heads



Diameter..............	1/4"	5/16"	3/8"	7/16"	1/2"	5/8"	3/4"	7/8"	1"	1 1/8"	1 1/4"
Threads per inch.......	20	18	16	14	13	11	10	9	8	7	7
Sizes of square and hexagon heads...	3/8 x 3/16	15/32 x 15/64	9/16 x 9/32	21/32 x 21/64	3/4 x 3/8	15/16 x 15/32	1 1/8 x 9/16	1 5/16 x 21/32	1 1/2 x 3/4	1 11/16 x 27/32	1 7/8 x 15/16

[Hoopes & Townsend, Phila., Pa.]

Planer Head Bolts



Dia. of screw.......	1/2"	9/16"	5/8"	11/16"	3/4"
Short dia. of head...	1 1/8"	1 1/8"	1 1/4"	1 1/4	1 7/16"
Thickness of head...	3/8"	3/8"	3/8"	3/8"	1/2"

Length under head to extreme point all sizes 1", 1 1/4", 1 1/2", 1 3/4", 2".

All sizes have 12 threads per inch.

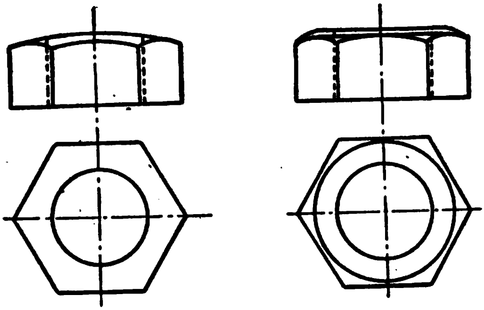
Bolts have either square or hexagon heads.

Nuts same size as heads.

[Hartford Machine Screw Co., Hartford, Conn.]

NUTS

For U. S. and Franklin Institute standard hexagon and square nuts see page 26. For S. A. E. (Society Automotive Engineers) hexagon nuts see page 29. Nuts can be obtained hot pressed, cold punched or milled from bars.

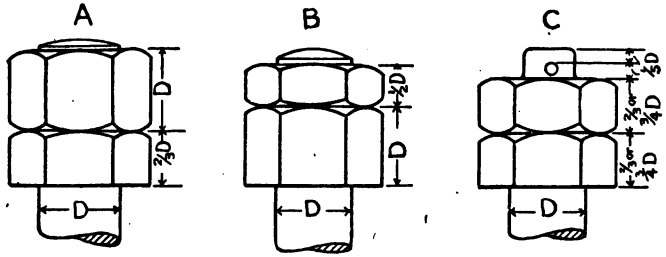


CHAMFERED   CHAMFERED AND TRIMMED

DEVICES TO PREVENT NUTS FROM COMING LOOSE

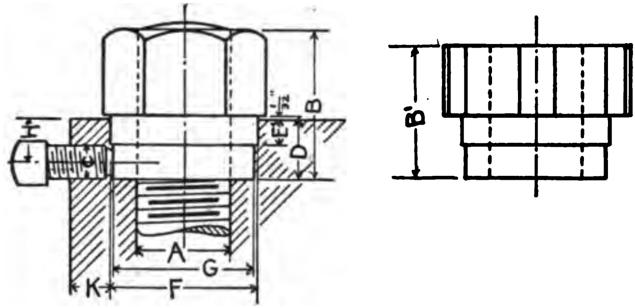
Nuts can be prevented from coming loose by lock or check nuts, set screws or split pins. In the latter case castellated nuts are often used. See pages 29 and 38.

LOCK OR CHECK NUTS



As the greatest load is on the top nut this should be the largest as shown in A. Spanners are seldom thin enough to take a thin bottom nut, and the nuts are sometimes arranged as in B which is convenient but faulty theoretically. C is a compromise of A and B, both nuts being the same size. Short diameter of nuts same as U. S. Standard—which see.

Nuts with Set Screws



Hexagon Head:

Head—Standard U. S. Nut.

A = dia. of bolt or stud

$B = 1\frac{1}{2}A + \frac{1}{8}''$

$C = \frac{A}{8} + \frac{1}{4}''$

$D = 1\frac{3}{4}C$

$E = H - \frac{C}{2}$.

$F = 1\frac{1}{2}A + \frac{1}{16}''$

$G = F - \frac{1}{32}''$; depth of G = C

$H = 1\frac{1}{8}C$

K for wrot iron and brass $= C + \frac{1}{16}''$

" " cast iron $= 1\frac{3}{16}C + \frac{1}{16}''$

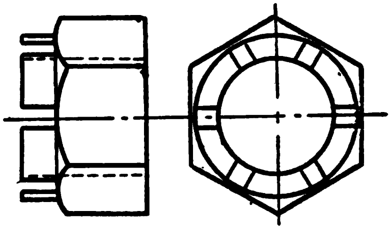
Slotted Head:

Head—see Slotted Nuts.

$B' = A + D$, other dimensions same as for hexagon head.

There is another type having a collar with the depth E and diameter F, below the ring with a diameter G. With this design the nut cannot slip by the set screw.

Castellated Hexagon Nuts



Screw Diameter	Total Thickness of Nut	Height of Castle	Diameter of Nut Across Flats of Hex.	Diameter of Castle	Diameter of Facing	Depth of Facing	Number of Slots in Castle	Depth of Slots in Castle (to round bottom)	Width of Slot in Castle	Diameter of Cotter Pin Used	Threads per inch
1/4	9/32	3/32	7/16	7/16	7/16	1/64	6	3/32	5/64	1/16	28
5/16	21/64	3/32	1/2	1/2	1/2	1/64	6	3/32	5/64	1/16	24
3/8	13/32	1/8	9/16	9/16	9/16	1/64	6	1/8	1/8	3/32	24
7/16	29/64	1/8	5/8	5/8	5/8	1/64	6	1/8	1/8	3/32	20
1/2	9/16	3/16	3/4	3/4	3/4	1/64	6	3/16	1/8	3/32	20
9/16	39/64	3/16	7/8	7/8	7/8	1/64	6	3/16	5/32	1/8	18
5/8	23/32	1/4	15/16	15/16	15/16	1/64	6	1/4	5/32	1/8	18
11/16	49/64	1/4	1	1	1	1/64	6	1/4	5/32	1/8	16
3/4	13/16	1/4	1 1/16	1 1/16	1 1/16	1/64	6	1/4	5/32	1/8	14
7/8	29/32	1/4	1 1/4	1 1/4	1 1/4	1/64	6	1/4	5/32	1/8	14

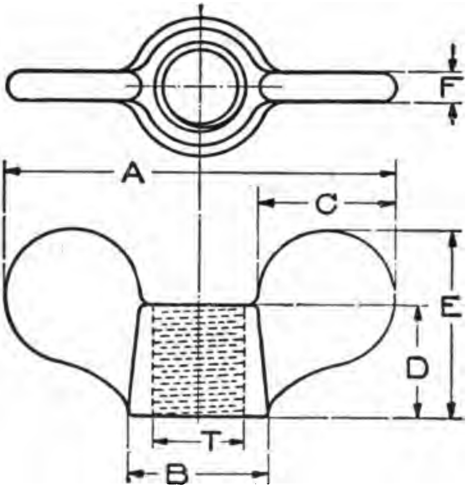
[Hartford Machine Screw Co., Hartford, Conn.]

This nut can be kept from coming loose by cotter pin through the slots. For Society Automotive Engineers castellated nut see page 29.

Planer Head Nuts

(See Planer Head Bolts)

Thumb or Wing Nuts



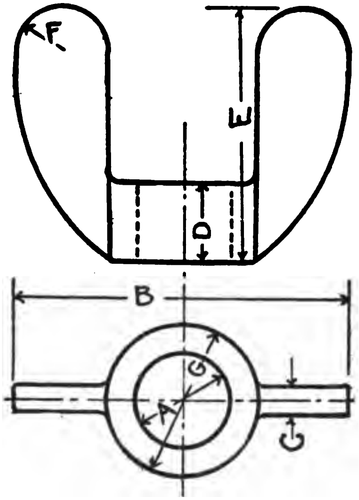
A	B	C	D	E	F	T
5/8	1/4	7/32	3/16	13/32	3/32	3/32*—56†
23/32	9/32	1/4	7/32	7/16	3/32	1/8 —40
13/16	5/16	9/32	1/4	17/32	1/8	5/32 —40
1 7/32	7/16	7/16	11/32	5/8	1/8	3/16 —24
1 5/16	1/2	15/32	3/8	11/16	5/32	1/4 —20
1 15/32	9/16	1/2	7/16	3/4	5/32	5/16 —18
1 21/32	5/8	9/16	1/2	13/16	5/32	3/8 —16
2 1/8	3/4	3/4	9/16	9/16	3/16	7/16 —14
2 5/16	13/16	13/16	5/8	5/8	3/16	1/2 —13
2 19/32	7/8	15/16	23/32	23/32	7/32	9/16 —12
2 31/32	1	1 1/16	13/16	13/16	1/4	5/8 —11
3 7/32	1 5/32	1 1/8	15/16	15/16	1/4	3/4 —10

[Billings & Spencer, Hartford, Conn.]

* Diameter.

† Threads per inch.

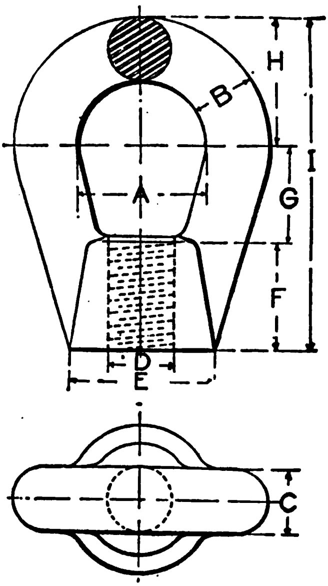
THUMB OR WING NUTS—*Continued*



A*	Threads per inch	B	C	D	E	F	G
3/16	24	1 1/8	3/16	3/16	1 1/8	3/16	3/8
1/4	20	1 1/4	3/16	3/16	1 1/4	3/16	1/2
5/16	18	1 5/8	3/16	1/4	1 3/8	1/4	5/8
3/8	16	1 11/16	1/4	5/16	1 9/16	1/4	11/16
7/16	14	2	1/4	3/8	1 5/8	5/16	3/4
1/2	13	2 1/8	5/16	7/16	1 3/4	5/16	7/8
5/8	11	2 5/8	5/16	9/16	1 7/8	3/8	1 1/8
3/4	10	2 11/16	5/16	5/8	2	3/8	1 3/16

* A can be tapped and threaded as thumb nuts on page 39. Wing nuts may be made of cast iron, composition or of drop forged steel.

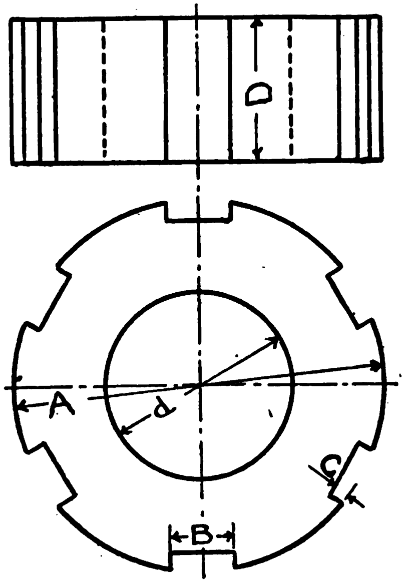
Eye Nuts



Size	A Inches	B Inches	C Inches	D In. U. S. S.	E Inches	F Inches	G Inches	H Inches	I Inches
3/8	7/8	5/16	1/4	3/8*-16†	3/4	3/4	3/4	3/4	2 1/4
1/2	1 1/8	7/16	3/8	1/2 -13	1	1	1	1	3
5/8	1 3/8	9/16	1/2	5/8 -11	1 1/4	1 1/4	1 1/4	1 1/4	3 3/4
3/4	1 1/2	3/4	3/4	3/4 -10	1 3/4	1 1/4	1 1/8	1 1/2	3 7/8
7/8	1 5/8	7/8	3/4	7/8 - 9	2	1 1/4	1	1 11/16	3 15/16
1	1 3/4	1	7/8	1 - 8	2 1/4	1 5/8	1 1/4	1 7/8	4 3/4
1 1/4	2	1 1/4	1 1/8	1 1/4 - 7	2 7/8	1 7/8	1 3/8	2 1/4	5 1/2
1 1/2	2 1/2	1 3/8	1 1/4	1 1/2 - 6	3 1/8	2 1/8	1 3/4	2 5/8	6 1/2
1 3/4	3	1 1/2	1 3/8	1 3/4 - 5	3 1/2	2 3/8	2	3	7 3/8
2	3 1/2	1 5/8	1 1/2	2 - 4 1/2	4	3	2 1/2	3 3/8	8 7/8

* Diameter.
† Threads per inch.

Slotted Round Nuts



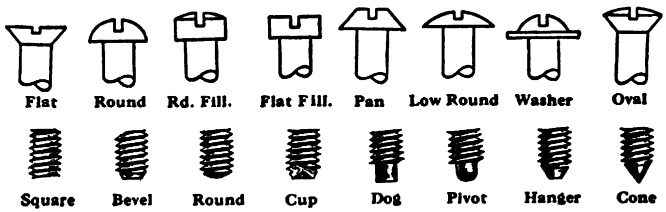
d = diameter of bolt.

A = .2d C = .13d

B = .3d D = .75d

SCREWS

STYLES OF HEADS AND SCREW POINTS



Note.—Rd. Fill. = Round Fillister. Flat Fill. = Flat Fillister.

Table of Decimal Equivalents of Screw Gauge

For Machine and Wood Screws, Brown & Sharpe Standard
The difference between consecutive sizes is .01316 inch

No. of Screw Gauge	Size in Decimals of in.	No. of Screw Gauge	Size in Decimals of in.	No. of Screw Gauge	Size in Decimals of in.
000	.03152	9	.17628	20	.32104
00	.04468	10	.18944	21	.33420
0	.05784	11	.20260	22	.34736
1	.07100	12	.21576	23	.36052
2	.08416	13	.22892	24	.37368
3	.09732	14	.24208	25	.38684
4	.11048	15	.25524	26	.40000
5	.12364	16	.26840	27	.41316
6	.13680	17	.28156	28	.42632
7	.14996	18	.29472	29	.43948
8	.16312	19	.30788	30	.45264

Wood Screws
(Standard and Drive)

Standard Wood Screws
(Iron and Brass)

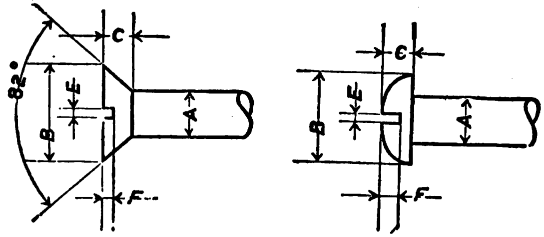

Flat Head


Round Head


Oval Head

Standard wood screws, if driven with a hammer, loose their holding power. Screws perpendicular to the grain have about 25% more holding power than those parallel to the grain.

Dimensions of Heads
(Standard Wood Screws)



Number of Screw Gauge	A Dia. in ins.	Flat Head				Round Head			
		B	C	E	F	B	C	E	F
0	.0578	.1105	.0303	.025	.0101	.1060	.0524	.025	.0314
1	.0710	.1368	.0378	.027	.0126	.1302	.0598	.027	.0359
2	.0842	.1631	.0454	.030	.0151	.1544	.0672	.030	.0403
3	.0973	.1894	.0530	.032	.0177	.1786	.0746	.032	.0448
4	.1105	.2158	.0605	.034	.0202	.2028	.0820	.034	.0492
5	.1236	.2421	.0681	.036	.0227	.2270	.0894	.036	.0536
6	.1368	.2684	.0757	.039	.0252	.2512	.0968	.039	.0580
7	.1500	.2947	.0832	.041	.0277	.2754	.1042	.041	.0625
8	.1631	.3210	.0908	.043	.0303	.2996	.1116	.043	.0670
9	.1763	.3474	.0984	.045	.0328	.3238	.1190	.045	.0714
10	.1894	.3737	.1059	.048	.0353	.3480	.1264	.048	.0758
11	.2020	.4000	.1135	.050	.0378	.3701	.1338	.050	.0803
12	.2158	.4263	.1210	.052	.0403	.3922	.1412	.052	.0847
13	.2289	.4526	.1286	.054	.0429	.4143	.1486	.054	.0891
14	.2421	.4790	.1362	.057	.0454	.4364	.1560	.057	.0936
15	.2552	.5053	.1438	.059	.0479	.4585	.1634	.059	.0980
16	.2684	.5316	.1513	.061	.0504	.4806	.1708	.061	.1024
17	.2816	.5579	.1589	.063	.0530	.5027	.1782	.063	.1069
18	.2947	.5842	.1665	.066	.0555	.5248	.1856	.066	.1114
20	.3210	.6368	.1816	.070	.0605	.5690	.2004	.070	.1202
22	.3474	.6865	.1967	.075	.0656	.6106	.2152	.075	.1291
24	.3737	.7421	.2118	.079	.0706	.6522	.2300	.079	.1380
26	.4000	.7948	.2270	.084	.0757	.6938	.2448	.084	.1469
28	.4263	.8474	.2421	.088	.0807	.7354	.2596	.088	.1558
30	.4526	.9000	.2573	.093	.0858	.7770	.2744	.093	.1646

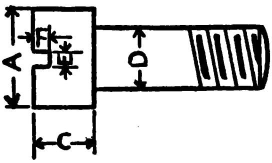
[Am. Screw Co., Prov., R. I.]

Diameter and Length (Standard Wood Screws)

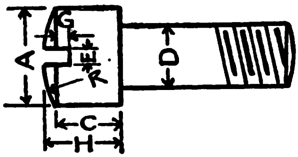
Number of Screw Gauge.	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	20	22	24	26	28	30
Diameter, ins..	.057	.071	.084	.097	.110	.123	.136	.150	.163	.176	.189	.203	.215	.228	.242	.255	.268	.281	.294	.321	.347	.374	.400	.426	.452
Length, ins....	¼ ⅜	¼ ⅜ ½ ⅝	¼ ⅜ ½ ⅝ ¾ ⅞	¼ ⅜ ½ ⅝ ¾ ⅞ 1 1¼	¼ ⅜ ½ ⅝ ¾ ⅞ 1 1¼ 1½	¼ ⅜ ½ ⅝ ¾ ⅞ 1 1¼ 1½	⅜ ½ ⅝ ¾ ⅞ 1 1¼ 1½ 1¾ 2	⅜ ½ ⅝ ¾ ⅞ 1 1¼ 1½ 1¾ 2	⅜ ½ ⅝ ¾ ⅞ 1 1¼ 1½ 1¾ 2 2¼	½ ⅝ ¾ ⅞ 1 1¼ 1½ 1¾ 2 2¼ 2½ 2¾	½ ⅝ ¾ ⅞ 1 1¼ 1½ 1¾ 2 2¼ 2½ 2¾ 3 3½	⅝ ¾ ⅞ 1 1¼ 1½ 1¾ 2 2¼ 2½ 2¾ 3 3½	⅝ ¾ ⅞ 1 1¼ 1½ 1¾ 2 2¼ 2½ 2¾ 3 3½ 4	⅝ ¾ ⅞ 1 1¼ 1½ 1¾ 2 2¼ 2½ 2¾ 3 3½ 4	⅝ ¾ ⅞ 1 1¼ 1½ 1¾ 2 2¼ 2½ 2¾ 3 3½ 4 4½	⅝ ¾ ⅞ 1 1¼ 1½ 1¾ 2 2¼ 2½ 2¾ 3 3½ 4 4½	⅝ ¾ ⅞ 1 1¼ 1½ 1¾ 2 2¼ 2½ 2¾ 3 3½ 4 4½ 5 6	1 1¼ 1½ 1¾ 2 2¼ 2½ 2¾ 3 3½ 4 4½ 5 6	1 1¼ 1½ 1¾ 2 2¼ 2½ 2¾ 3 3½ 4 4½ 5 6	1¼ 1½ 1¾ 2 2¼ 2½ 2¾ 3 3½ 4 4½ 5 6	1½ 1¾ 2 2¼ 2½ 2¾ 3 3½ 4 4½ 5 6	2¼ 2½ 2¾ 3 3½ 4 4½ 5 6	3 3½ 4 4½ 5 6	3 3½ 4 4½ 5 6	3 3½ 4 4½ 5 6

For dimensions of heads, see page 44. Wood screws are sold by the gross.

Cap Screws



FLAT FILLISTER OR ROUND HEAD



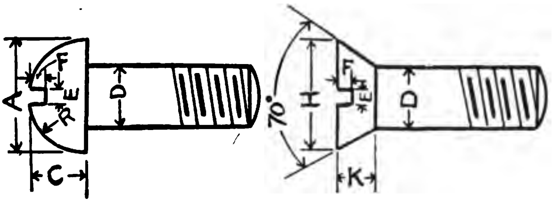
OVAL FILLISTER HEAD

D and C	A	Threads per in.	E	F	G	H	R
1/8	3/16	40	.032	1/16	5/64	9/64	1/4
3/16	1/4	24	.040	1/16	3/32	7/32	5/16
1/4	3/8	20	.064	1/16	3/32	9/32	1/2
5/16	7/16	18	.072	5/64	1/8	23/64	5/8
3/8	9/16	16	.091	3/32	9/64	15/32	3/4
7/16	5/8	14	.102	7/64	11/64	1/2	7/8
1/2	3/4	13	.114	1/8	3/16	9/16	1 1/16
9/16	13/16	12	.114	9/64	7/32	41/64	1 1/8
5/8	7/8	11	.128	5/32	15/64	45/64	1 1/4
3/4	1	10	.133	3/16	9/32	27/32	1 1/2
7/8	1 1/8	9	.133	7/32	21/64	63/64	1 5/8
1	1 1/4	8	..165	1/4	3/8	1 1/8	1 3/4

SQUARE AND HEXAGON HEADS

Dia. of screw......	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1	1 1/8	1 1/4
Dia. of sq. head....	3/8	7/16	1/2	9/16	5/8	11/16	3/4	7/8	1 1/8	1 1/4	1 3/8	1 1/2
Dia. of hex. head...	7/16	1/2	9/16	5/8	3/4	13/16	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
Height of sq. and hex. heads.......	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1	1 1/8	1 1/4

CAP SCREWS—*Continued*



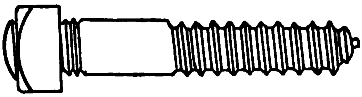
BUTTON HEAD FLAT OR COUNTERSUNK HEAD

D	A	C	E	F	R	H	K
1/8	7/32	7/64	.035	3/64	7/64	1/4	3/32
3/16	5/16	5/32	.051	1/16	5/32	3/8	9/64
1/4	7/16	7/32	.072	3/64	7/32	15/32	5/32
5/16	9/16	9/32	.091	3/32	9/32	5/8	7/32
3/8	5/8	5/16	.102	7/64	5/16	3/4	17/64
7/16	3/4	3/8	.114	1/8	3/8	13/16	17/64
1/2	13/16	13/32	.114	5/32	13/32	7/8	17/64
9/16	15/16	15/32	.114	11/64	15/32	1	5/16
5/8	1	1/2	.133	3/16	1/2	1 1/8	23/64
3/4	1 1/4	5/8	.133	7/32	5/8	1 3/8	7/16

On all screws of 1 inch and less in diameter, and 4 inches long and under, threads are cut three quarters of the length. Longer than 4 inches, threads are cut one-half of length. Cap screws are also made with hexagon heads. For number of threads per inch, see table, page 46.

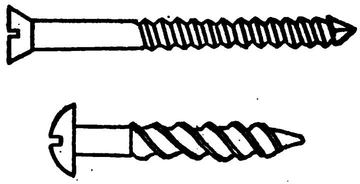
[Atlas Bolt & Screw Co., Cleveland, Ohio.]

HANGER SCREWS



Dias. 3/8", 7/16", 1/2", 5/8", 3/4", 7/8," 1". Overall lengths from 2 1/2" up, advancing by 1/2".

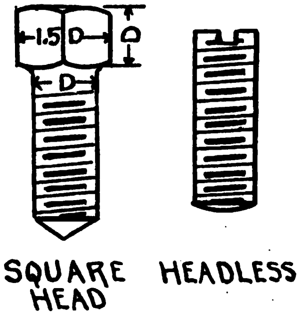
Drive Screws



Dimensions of Flat, Round and Oval Heads

Number of screw gauge	4	5	6	7	8	9	10	11	12	13	14	15	16	18	20
Diameter, ins.........	.110	.123	.136	.150	.163	.176	.189	.203	.215	.228	.242	.255	.268	.294	.321
Length, ins...........	½ ⅝ ¾ ⅞ 1 1¼ 1½	½ ⅝ ¾ ⅞ 1 1¼ 1½ 1¾ 2 2¼ 2½	½ ⅝ ¾ ⅞ 1 1¼ 1½ 1¾ 2 2¼ 2½ 2¾ 3	½ ⅝ ¾ ⅞ 1 1¼ 1½ 1¾ 2 2¼ 2½ 2¾ 3	½ ⅝ ¾ ⅞ 1 1¼ 1½ 1¾ 2 2¼ 2½ 2¾ 3 3½ 4	½ ⅝ ¾ ⅞ 1 1¼ 1½ 1¾ 2 2¼ 2½ 2¾ 3 3½ 4	½ ⅝ ¾ ⅞ 1 1¼ 1½ 1¾ 2 2¼ 2½ 2¾ 3 3½ 4	½ ⅝ ¾ ⅞ 1 1¼ 1½ 1¾ 2 2¼ 2½ 2¾ 3 3½ 4	½ ⅝ ¾ ⅞ 1 1¼ 1½ 1¾ 2 2¼ 2½ 2¾ 3 3½ 4	⅝ ¾ ⅞ 1 1¼ 1½ 1¾ 2 2¼ 2½ 2¾ 3 3½ 4	⅝ ¾ ⅞ 1 1¼ 1½ 1¾ 2 2¼ 2½ 2¾ 3 3½ 4	¾ ⅞ 1 1¼ 1½ 1¾ 2 2¼ 2½ 2¾ 3 3½ 4	¾ ⅞ 1 1¼ 1½ 1¾ 2 2¼ 2½ 2¾ 3 3½ 4	1 1¼ 1½ 1¾ 2 2¼ 2½ 2¾ 3 3½ 4	1 1¼ 1½ 1¾ 2 2¼ 2½ 2¾ 3 3½ 4

Set Screws

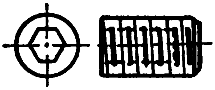


D = dia. of screw.

Dia. of screw......	¼	5/16	⅜	7/16	½	9/16	⅝	¾	⅞	1	1⅛	1¼
Threads per inch..	20	18	16	14	12 or 13	12	11	10	9	8	7	7

May be obtained with conical, dog, oval, cup or flat points. See page 42.

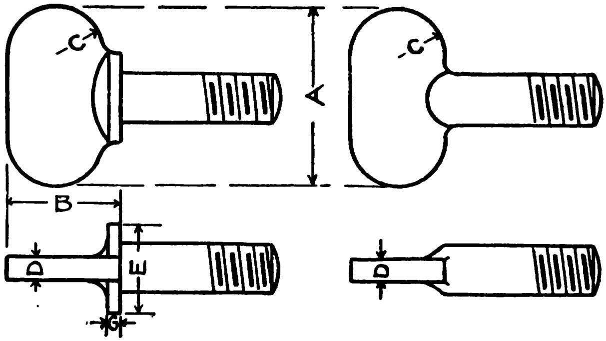
Safety or Socket Set Screws



Dias in ins.	Length ins.	U. S. Standard Threads per in.
¼	5/16	20
5/16	5/16 or ⅜	18
⅜	⅜ " ½	16
7/16	7/16 " ½	14
½	½ " ⅝	13
9/16	9/16	12
⅝	⅝ " ¾	11
¾	¾ " 1	10
⅞	⅞ " 1⅛	9.
1	1 " 1¼	8

[Hartford Mach. Screw Co., Hartford, Conn.]

Thumb Screws



SHOULDER PLAIN

Dia.	Threads per inch	A	B	C	D	E*	G*
3/16	24	3/4	1/2	3/16	1/8	3/8	3/32
1/4	20	1	5/8	1/4	1/8	7/16	3/32
5/16	18	1 1/8	3/4	5/16	3/16	9/16	3/32
3/8	16	1 1/4	7/8	3/8	3/16	5/8	1/8
7/16	14	1 1/2	1	7/16	1/4	3/4	1/8
1/2	13	1 3/4	1 1/8	1/2	1/4	7/8	1/8

* E and G apply only to shoulder thumb screws.

Length of Screws

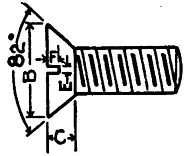
Dia.	Length							
3/16	1/2	3/4	1	1 1/4	1 1/2	2	...	...
1/4	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3
5/16	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3
3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3
7/16	...	...	1	1 1/4	1 1/2	2	2 1/2	3
1/2	...	...	1	1 1/4	1 1/2	2	2 1/2	3

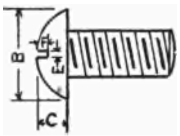
Coach or Lag Screws

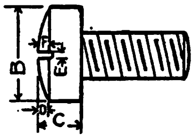
Cone or gimlet points. Screws with gimlet points can be obtained from 5/16″ to 3/4″ dia. Square or hexagon heads.

Diameter of Screw (Inches)										Approximate length of thread for all diameters
1/4 & 5/16	3/8	7/16	1/2	9/16 & 5/8	3/4	7/8	1	1 1/8	1 1/4	
Length under head to point (inches)										
1 1/2	1 1/2	1 1/2	1 1/2							To head
2	2	2	2	2						1 1/2
2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2					2
3	3	3	3	3	3	3				2 1/4
3 1/2	3 1/2	3 1/2	3 1/2	3 1/2	3 1/2	3 1/2	3 1/2			2 1/2
4	4	4	4	4	4	4	4			3
4 1/2	4 1/2	4 1/2	4 1/2	4 1/2	4 1/2	4 1/2	4 1/2			3 1/2
5	5	5	5	5	5	5	5	5		4
5 1/2	5 1/2	5 1/2	5 1/2	5 1/2	5 1/2	5 1/2	5 1/2	5 1/2		4
6	6	6	6	6	6	6	6	6	6	4 1/2
		6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	6 1/2	5
		7	7	7	7	7	7	7	7	5
		7 1/2	7 1/2	7 1/2	7 1/2	7 1/2	7 1/2	7 1/2	7 1/2	6
		8	8	8	8	8	8	8	8	6
		9	9	9	9	9	9	9	9	6
			10	10	10	10	10	10	10	7
			11	11	11	11	11	11	11	7
			12	12	12	12	12	12	12	7
Threads per inch										
10	7	7	6	5	4 1/2	4 1/2	3	3	3	
Size of heads (square and hexagon)										
3/8 15/32	9/16	21/32	3/4	27/32 15/16	1 1/8	1 5/16	1 1/2	1 11/16	1 7/8	Width across flats
3/16 15/64	9/32	21/64	3/8	27/64 15/32	9/16	21/32	3/4	27/32	15/16	Thickness

Standard Machine Screws—Dimensions







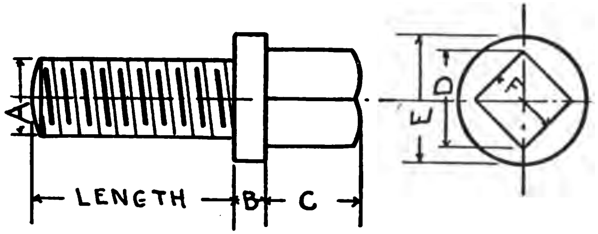
Number of Screw Gauge	Diameter in Inches	Flat Head				Round Head				Fillister Head				
		B	C	E	F	B	C	E	F	B	C	D*	E	F*
2	.0842	.1631	.0454	.030	.0151	.1544	.0672	.030	.0403	.1350	.0549	.0126	.030	.0338
3	.0973	.1894	.0530	.032	.0177	.1786	.0746	.032	.0448	.1561	.0634	.0146	.032	.0390
4	.1105	.2158	.0605	.034	.0202	.2028	.0820	.034	.0492	.1772	.0720	.0166	.034	.0443
5	.1236	.2421	.0681	.036	.0227	.2270	.0894	.036	.0536	.1984	.0806	.0186	.036	.0496
6	.1368	.2684	.0757	.039	.0252	.2512	.0968	.039	.0580	.2195	.0892	.0205	.039	.0549
7	.1500	.2947	.0832	.041	.0277	.2754	.1042	.041	.0625	.2406	.0978	.0225	.041	.0602
8	.1631	.3210	.0908	.043	.0303	.2996	.1116	.043	.0670	.2617	.1063	.0245	.043	.0654
9	.1763	.3474	.0984	.045	.0328	.3238	.1190	.045	.0714	.2828	.1149	.0265	.045	.0707
10	.1894	.3737	.1059	.048	.0353	.3480	.1264	.048	.0758	.3040	.1235	.0285	.048	.0760
12	.2158	.4263	.1210	.052	.0403	.3922	.1412	.052	.0847	.3462	.1407	.0324	.052	.0866
14	.2421	.4790	.1362	.057	.0454	.4364	.1560	.057	.0936	.3884	.1578	.0364	.057	.0971
16	.2684	.5316	.1513	.061	.0504	.4806	.1708	.061	.1024	.4307	.1750	.0403	.061	.1077
18	.2947	.5842	.1665	.066	.0555	.5248	.1856	.066	.1114	.4729	.1921	.0443	.066	.1182
20	.3210	.6368	.1816	.070	.0605	.5690	.2004	.070	.1202	.5152	.2093	.0483	.070	.1288
22	.3474	.6895	.1967	.075	.0656	.6106	.2152	.075	.1291	.5574	.2267	.0520	.075	.1384
24	.3737	.7421	.2118	.079	.0706	.6522	.2300	.079	.1380	.5996	.2436	.0562	.079	.1499
26	.4000	.7421	.1967	.084	.0656	.6938	.2448	.084	.1469	.6419	.2608	.0601	.084	.1605
28	.4263	.7948	.2118	.088	.0706	.7354	.2596	.088	.1558	.6841	.2779	.0641	.088	.1710
30	.4526	.8474	.2270	.093	.0757	.7770	.2744	.093	.1646	.7264	.2951	.0681	.093	.1816

D* = round of head. F* = depth of slot. For threads per inch and size of drill see page 53.

Standard Machine Screw—Threads per Inch and Size of Drill

Screw Gauge	Dia. of body ins.	Threads per in.	No. of drill	Size of drill ins.	Screw Gauge	Dia. of body ins.	Threads per in.	No. of drill	Size of drill ins.
2	.0842	48, 56, 64	49	.0730	14	.2421	18, 20, 24	13	.1850
3	.0973	48, 56	45	.0820	16	.2684	16, 18, 20	6	.2040
4	.1105	32, 36, 40	42	.0935	18	.2947	16, 18, 20	1	.2280
5	.1236	32, 36, 40	38	.1015	20	.3210	16, 18	D	.246
6	.1368	30, 32, 36	35	.1100	22	.3474	16, 18	J	.277
7	.1500	30, 32	30	.1285	24	.3737	14, 16, 18	N	.302
8	.1631	30, 32, 36	29	.1360	26	.4000	14, 16	P	.323
9	.1763	24, 30, 32	27	.1440	28	.4263	14, 16	R	.339
10	.1894	24, 30, 32	25	.1495	30	.4526	14, 16	U	.368
12	.2158	20, 24	17	.1730					

Collar Screws

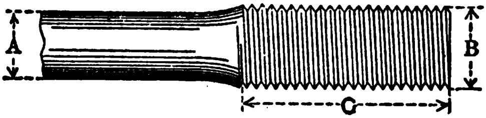


A	Threads per in.	B	C	D	E	F
5/16	18	9/64	7/16	27/64	17/32	5/16
3/8	16	5/32	1/2	33/64	5/8	3/8
7/16	14	11/64	9/16	19/32	23/32	7/16
1/2	13	3/16	5/8	11/16	13/16	1/2
5/8	11	7/32	3/4	55/64	1	5/8
3/4	10	1/4	7/8	31/32	1 3/16	3/4
7/8	9	9/32	1	1 5/32	1 3/8	7/8
1	8	5/16	1 1/8	1 3/8	1 9/16	1
1 1/8	7	11/32	1 1/4	1 35/64	1 3/4	1 1/8
1 1/4	6	3/8	1 3/8	1 23/32	1 15/16	1 1/4

[Cincinnati Bickford Tool Co., Cincinnati, Ohio]

Lengths from 3/4″ to 6 1/2″ advancing by 1/4″.

Upset Screw Ends for Round Bars

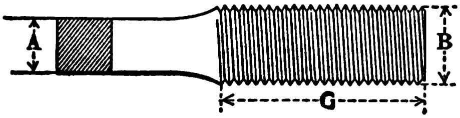


Diameter of Bar	Area of Body of Bar	Diameter of Screw	Length of Upset	Area at Root of Thread	Number of Threads per Inch	Weight per Foot of Steel Bar	Add for Upset	Excess of Area at Root of Thread over that of Body of Bar
A		B	C					
Inches	Sq. Ins.	Inches	Inches	Sq. Ins.		Pounds	Inches	Per Cent
1/2	.196	3/4	4 1/4	.302	10	.668	6 1/2	54
9/16	.249	3/4	4 1/4	.302	10	.845	4 1/4	21
5/8	.307	7/8	4 1/2	.420	9	1.043	5 1/2	37
11/16	.371	1	4 1/2	.550	8	1.262	6 1/4	48
3/4	.442	1	4 1/2	.550	8	1.502	4 1/2	25
13/16	.519	1 1/8	4 3/4	.694	7	1.763	5 1/2	34
7/8	.601	1 1/4	4 3/4	.893	7	2.044	6 1/4	49
15/16	.690	1 1/4	4 3/4	.893	7	2.347	4 1/2	29
1	.785	1 3/8	5	1.057	6	2.670	5 1/4	35
1 1/16	.887	1 3/8	5	1.057	6	3.014	4 1/4	19
1 1/8	.994	1 1/2	5	1.295	6	3.379	4 3/4	30
1 3/16	1.108	1 1/2	5	1.295	6	3.766	3 3/4	17
1 1/4	1.227	1 5/8	5 1/4	1.515	5 1/2	4.173	4 1/2	23
1 5/16	1.353	1 3/4	5 1/4	1.744	5	4.600	5	29
1 3/8	1.485	1 3/4	5 1/4	1.744	5	5.049	4	18
1 7/16	1.623	1 7/8	5 1/2	2.048	5	5.518	4 3/4	26
1 1/2	1.767	2	5 1/2	2.302	4 1/2	6.008	5 1/4	30
1 9/16	1.918	2	5 1/2	2.302	4 1/2	6.520	4 1/2	20
1 5/8	2.074	2 1/8	5 3/4	2.650	4 1/2	7.051	5	28
1 11/16	2.237	2 1/8	5 3/4	2.650	4 1/2	7.604	4 1/4	18

UPSET SCREW ENDS FOR ROUND BARS—*Continued*

Diameter of Bar A	Area of Body of Bar	Diameter of Screw B	Length of Upset C	Area at Root of Thread	Number of Threads per Inch	Weight per Foot of Steel Bar	Add for Upset	Excess of Area at Root of Thread over that of Body of Bar
Inches	Sq. Ins.	Inches	Inches	Sq. Ins.		Pounds	Inches	Per Cent
1¾	2.405	2¼	5¾	3.023	4½	8.178	4¾	26
1$\frac{13}{16}$	2.580	2¼	5¾	3.023	4½	8.773	4	17
1⅞	2.761	2⅜	6	3.419	4½	9.388	4½	24
1$\frac{15}{16}$	2.948	2½	6	3.715	4	10.020	5	26
2	3.142	2½	6	3.715	4	10.68	4¼	18
2$\frac{1}{16}$	3.341	2⅝	6¼	4.155	4	11.36	4¾	24
2⅛	3.547	2⅝	6¼	4.155	4	12.06	4	17
2$\frac{3}{16}$	3.758	2¾	6¼	4.619	4	12.78	4½	23
2¼	3.976	2⅞	6½	5.108	4	13.52	5¼	28
2$\frac{5}{16}$	4.200	2⅞	6½	5.108	4	14.28	4½	22
2⅜	4.430	3	6½	5.428	3½	15.07	4¾	23
2$\frac{7}{16}$	4.666	3⅛	6¾	5.957	3½	15.86	5½	28
2½	4.909	3⅛	6¾	5.957	3½	16.69	4¾	21
2$\frac{9}{16}$	5.157	3¼	6¾	6.510	3½	17.53	5¼	26
2⅝	5.412	3¼	6¾	6.510	3½	18.40	4½	20
2$\frac{11}{16}$	5.673	3⅜	7	7.087	3½	19.29	5	25
2¾	5.940	3⅜	7	7.087	3½	20.20	4½	19
2$\frac{13}{16}$	6.213	3½	7	7.548	3¼	21.12	4¾	22
2⅞	6.492	3⅝	7¼	8.171	3¼	22.07	5¼	26
2$\frac{15}{16}$	6.777	3⅝	7¼	8.171	3¼	23.04	4¾	21
3	7.069	3¾	7¼	8.641	3	24.03	5	22
3⅛	7.670	3⅞	7½	9.305	3	26.08	5¼	21
3¼	8.296	4	7½	9.993	3	28.20	4¾	20
3⅜	8.946	4⅛	7¾	10.706	3	30.42	4¾	20
3½	9.621	4¼	8	11.329	2⅞	32.71	4½	18
3⅝	10.321	4½	8	12.743	2¾	35.09	5¼	23
3¾	11.045	4⅝	8¼	13.544	2¾	37.56	5¼	23
3⅞	11.793	4¾	8½	14.220	2⅝	40.10	5	21
4	12.566	5	8½	15.763	2½	42.73	5¼	25

Upset Screw Ends for Square Bars



Side of Square Bar A	Area of Body of Bar	Diameter of Screw B	Length of Upset C	Area at Root of Thread	Number of Threads per Inch	Weight per Foot of Steel Bar	Add for Upset	Excess of Area at Root of Thread Over that of Body of Bar
Inches	Sq. Ins.	Inches	Inches	Sq. Ins.		Pounds	Inches	Per Cent
½	.250	¾	4¼	.302	10	.850	4	21
9/16	.316	⅞	4½	.420	9	1.076	5	33
⅝	.391	1	4½	.550	8	1.328	5¾	41
11/16	.473	1	4½	.550	8	1.607	3¾	17
¾	.563	1⅛	4¾	.694	7	1.913	4½	23
13/16	.660	1¼	4¾	.893	7	2.245	5	35
⅞	.766	1⅜	5	1.057	6	2.603	5¾	38
15/16	.879	1⅜	5	1.057	6	2.989	4¼	20
1	1.000	1½	5	1.295	6	3.400	4¾	29
1 1/16	1.129	1⅝	5¼	1.515	5½	3.838	5½	34
1⅛	1.266	1⅝	5¼	1.515	5½	4.303	4¼	20
1 3/16	1.410	1¾	5¼	1.744	5	4.795	4¾	24
1¼	1.563	1⅞	5½	2.048	5	5.312	5¼	31
1 5/16	1.723	1⅞	5½	2.048	5	5.851	4¼	19
1⅜	1.891	2	5½	2.302	4½	6.428	4½	22
1 7/16	2.066	2⅛	5¾	2.650	4½	7.026	5¼	28
1½	2.250	2⅛	5¾	2.650	4½	7.650	4¼	18
1 9/16	2.441	2¼	5¾	3.023	4½	8.300	4½	24
1⅝	2.641	2⅜	6	3.419	4½	8.978	5	30
1 11/16	2.848	2⅜	6	3.419	4½	9.682	4¼	20
1¾	3.063	2½	6	3.715	4	10.410	4½	21
1 13/16	3.285	2⅝	6¼	4.155	4	11.170	5	26
1⅞	3.516	2⅝	6¼	4.155	4	11.950	4¼	18
1 15/16	3.754	2¾	6¼	4.619	4	12.760	4½	23

UPSET SCREW ENDS FOR SQUARE BARS—*Continued*

Side of Square Bar A	Area of Body of Bar	Diameter of Screw B	Length of Upset C	Area at Root of Thread	Number of Threads per Inch	Weight per Foot of Bar	Add for Upset	Excess of Area at Root of Thread Over that of Body of Bar
Inches	Sq. Ins.	Inches	Inches	Sq. Ins.		Pounds	Inches	Per Cent
2	4.000	2⅞	6½	5.108	4	13.60	5	28
2 1/16	4.254	2⅞	6½	5.108	4	14.46	4¼	20
2⅛	4.516	3	6½	5.428	3½	15.35	4½	20
2 3/16	4.785	3⅛	6¾	5.957	3½	16.27	5	24
2¼	5.063	3⅛	6¾	5.957	3½	17.22	4¼	18
2 5/16	5.348	3¼	6¾	6.510	3½	18.19	4¾	22
2⅜	5.641	3⅜	7	7.087	3½	19.18	5¼	26
2 7/16	5.941	3⅜	7	7.087	3½	20.20	4½	19
2½	6.250	3½	7	7.548	3¼	21.25	4¾	21
2 9/16	6.566	3⅝	7¼	8.171	3¼	22.33	5¼	24
2⅝	6.891	3⅝	7¼	8.171	3¼	23.43	4½	19
2 11/16	7.223	3¾	7¼	8.641	3	24.56	4¾	20
2¾	7.563	3⅞	7½	9.305	3	25.71	5¼	23
2 13/16	7.910	3⅞	7½	9.305	3	26.90	4½	18
2⅞	8.266	4	7½	9.993	3	28.10	4¾	21
2 15/16	8.629	4⅛	7½	10.706	3	29.34	5	24
3	9.000	4⅛	7¾	10.706	3	30.60	4½	19
3⅛	9.766	4⅜	8	12.087	2⅞	33.20	5¼	24
3¼	10.563	4½	8	12.743	2¾	35.92	5	21
3⅜	11.391	4⅝	8¼	13.544	2¾	38.73	5	19
3½	12.250	4⅞	8½	15.068	2⅝	41.65	5½	23
3⅝	13.141	5	8½	15.763	2½	44.68	5¼	20
3¾	14.063	5⅛	8¾	16.658	2½	47.82	5	18
3⅞	15.016	5¼	8¾	17.572	2½	51.05	4¾	17
4	16.000	5½	9	19.267	2⅜	54.40	5¼	20

The weight of steel in round and square bars (pages 54 and 56) is 486.9 lb. per cu. ft. or .28 lb. per cu. in.

THREADS FOR BOLTS, NUTS, SCREWS AND PIPE

Definitions

(National Screw Thread Commission, Washington, D. C.)

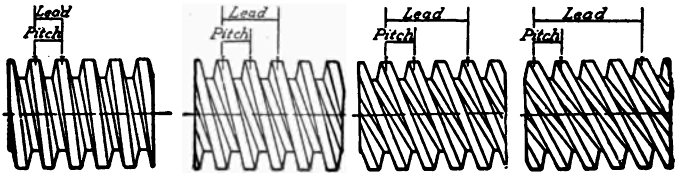
Screw Thread.—A ridge of uniform section wound in the form of a helix on the inside or outside surface of a cylinder or cone.

Screw Helix.—The path of a point moving at a uniform angular rate on a cylindrical or conical surface and at the same time moving at a uniform axial rate.

Major Diameter (formerly known as outside diameter).—The largest diameter of the thread on the screw or nut. The term major diameter replaces the term outside diameter as applied to the thread of a screw and also the term full diameter as applied to the thread of a nut.

Minor Diameter (formerly known as core diameter).—The smallest diameter of the thread on the screw or nut. The term minor diameter replaces the term core diameter as applied to the thread of a screw and also the term inside diameter as applied to the thread of a nut.

Pitch Diameter.—On a straight screw thread the diameter of an imaginary cylinder which would pass through the threads at such points as to make the width of the threads and the width of the spaces cut by the surface of the cylinder equal.



Single Double Triple Quadruple

Pitch.—The distance from a point on a screw thread to a corresponding point on the next thread measured parallel to the axis.

$$\text{Pitch} = \frac{1}{\text{Number of threads per inch.}}$$

Lead.—The distance a screw thread advances axially in one turn. On a single thread screw, the lead and pitch are identical; on a double thread screw the lead is twice the pitch, on a triple thread screw the lead is three times the pitch, etc.

Angle of Thread.—The angle included between the sides of the thread measured in an axial plane.

Helix angle.—The angle made by the helix of the thread at the pitch diameter with a plane perpendicular to the axis.

Crest.—The top surface joining the two sides of a thread.

Root.—The bottom surface joining the sides of two adjacent threads.

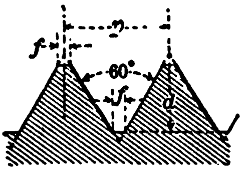
Crest Clearance.—Defined on a screw form as the space between the top of a thread and the root of its mating thread.

Fit.—The relation between two mating parts with reference to ease of assembly, for example:

Wrench fit	Medium fit
Close fit	Loose fit

The quality of fit is dependent upon both the relative size and the quality of finish of the mating parts.

Threads for Bolts and Nuts
United States Standard



$$p = \text{pitch} = \frac{1}{\text{No. thds. per in.}}$$

$$d = \text{depth} = p \times .64952$$

$$f = \text{flat} = \frac{p}{8}$$

Dia.	No. of Threads per Inch	Dia. at Root of Thread	Dia. of Tap Drill	Area in Square Inches: Bolt	Area in Square Inches: Bottom of Thread	Tensile Strength at Stress of 6000 lbs. per Sq. In.	Working Strength at Stress of 6000 lbs. per Sq. In.
1/4	20	0.185	13/64	0.049	0.026	160	....
5/16	18	0.240	1/4	0.076	0.045	270	....
3/8	16	0.294	5/16	0.110	0.068	410	....
7/16	14	0.345	23/64	0.150	0.093	560	....
1/2	13	0.400	27/64	0.196	0.126	760	....
9/16	12	0.454	15/32	0.248	0.162	1000	....
5/8	11	0.507	17/32	0.307	0.202	1210	260
3/4	10	0.620	41/64	0.442	0.302	1810	680
7/8	9	0.731	3/4	0.601	0.419	2520	1210

(Continued on page 60)

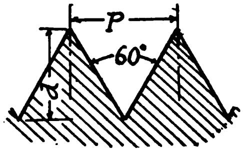
Threads for Bolts and Nuts—*Continued*

United States Standard

Dia.	No. of Threads per Inch	Dia. at Root of Thread	Dia. of Tap Drill	Area in Square Inches		Tensile Strength at Stress of 6000 lbs. per Sq. In.	Working Strength at Stress of 6000 lbs. per Sq. In.
				Bolt	Bottom of Thread		
1	8	0.838	55/64	0.785	0.551	3300	1790
1 1/8	7	0.939	31/32	0.994	0.694	4160	2470
1 1/4	6	1.064	1 3/32	1.227	0.893	5350	3470
1 3/8	6	1.158	1 7/32	1.485	1.057	6340	4260
1 1/2	6	1.283	1 11/32	1.767	1.295	7770	5500
1 5/8	5 1/2	1.389	1 27/64	1.074	1.515	9090	6630
1 3/4	5	1.490	1 17/32	2.405	1.746	10470	7830
1 7/8	5	1.615	1 21/32	2.761	2.051	12300	9470
2	4 1/2	1.711	1 49/64	3.142	2.302	13800	10800
2 1/4	4 1/2	1.961	2 1/64	3.976	3.023	18100	14700
2 1/2	4	2.175	2 15/64	4.909	3.719	22300	18500
2 3/4	4	2.425	2 31/64	5.940	4.602	27700	23600
3	3 1/2	2.629	2 11/16	7.069	5.428	32500	28000
3 1/4	3 1/2	2.879	2 15/16	8.296	6.510	39000	34100
3 1/2	3 1/4	3.100	3 11/64	9.621	7.548	45300	40000
3 3/4	3	3.317	3 3/8	11.045	8.641	51800	45000
4	3	3.567	3 5/8	12.566	9.963	59700	50100
4 1/4	2 7/8	3.798	3 27/32	14.186	11.340	68000	58000
4 1/2	2 3/4	4.028	4 3/32	15.904	12.750	76500	66000
4 3/4	2 5/8	4.255	4 5/16	17.721	14.215	85500	74000
5	2 1/2	4.480	4 9/16	19.635	15.760	94000	82500
5 1/4	2 1/2	4.730	4 13/16	21.648	17.570	105500	93000
5 1/2	2 3/8	4.953	5 1/32	23.758	19.260	116000	103000
5 3/4	2 3/8	5.203	5 9/32	25.967	21.250	127000	114000
6	2 1/4	5.423	5 1/2	28.274	23.090	138000	124000

Tap drill sizes given provide for a slight clearance at the root of thread to facilitate tapping and reduce tap breakage. Where full threads are required use the diameters specified for root of thread.

V Threads

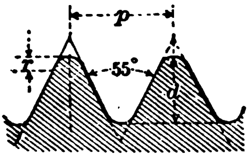


$$p = \text{pitch} = \frac{1}{\text{Number of threads per in.}}$$

$$d = \text{depth} = p \times .866$$

Whitworth Threads

(Standard in Great Britain)



$$p = \text{pitch} = \frac{1}{\text{Number of threads per in.}}$$

$$d = \text{depth} = p \times .64033$$

$$r = \text{radius} = p \times .1373$$

Diameter Ins.	Threads per in.	Diameter at Root of Thread	Radius	Diameter Ins.	Threads per Inch	Diameter at Root of Thread	Radius
1/4	20	.186	.0069	1 7/8	4 1/2	1.590	.0305
5/16	18	.241	.0076	2	4 1/2	1.715	.0305
3/8	16	.295	.0086	2 1/4	4	1.930	.0343
7/16	14	.346	.0098	2 1/2	4	2.180	.0343
1/2	12	.393	.0114	2 3/4	3 1/2	2.384	.0393
9/16	12	.456	.0114	3	3 1/2	2.634	.0393
5/8	11	.508	.0125	3 1/4	3 1/4	2.856	.0422
3/4	10	.622	.0137	3 1/2	3 1/4	3.105	.0422
7/8	9	.732	.0152	3 3/4	3	3.320	.0458
1	8	.840	.0176	4	3	3.573	.0458
1 1/8	7	.942	.0196	4 1/2	2 7/8	4.0546	.0477
1 1/4	7	1.067	.0196	5	2 3/4	4.5343	.0499
1 3/8	6	1.161	.0229	5 1/2	2 5/8	5.0121	.0523
1 1/2	6	1.286	.0229	6	2 1/2	5.4877	.0549
1 5/8	5	1.368	.0275				
1 3/4	5	1.494	.0275				

British Standard Fine Threads

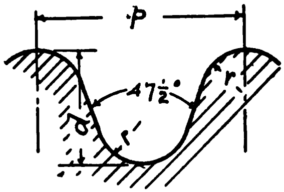
British standard fine threads have the same form as Whitworth,

but in the British there are more threads per inch.

Dia.	Threads per in.	Dia.	Threads per in.	Dia.	Threads per in.
1/4	26	9/16	16	1	10
9/32	26	5/8	14	1 1/8	9
5/16	22	11/16	14	1 1/4	9
3/8	20	3/4	12	1 3/8	8
7/16	18	13/16	12	1 1/2	8
1/2	16	7/8	11		

British Association Standard Thread (B. A. S.)

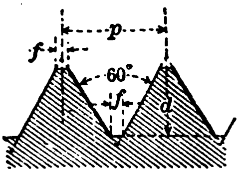
(Used for small screws)



$$r = \frac{2p}{11} \quad d = .6p$$

Brit. Ass'n Number	Dia.		Pitch		Dia. at root of thread Mm.	Brit. Ass'n Number	Dia.		Pitch		Dia. at root of thread Mm.
	Ins.	Mm.	Ins.	Mm.			Ins.	Mm.	Ins.	Mm.	
0	.236	6.0	.0394	1.00	4.8	13	.047	1.20	.0098	.25	.90
1	.209	5.3	.0354	.90	4.22	14	.039	1.00	.0091	.23	.72
2	.185	4.7	.0319	.81	3.73	15	.035	.90	.0083	.21	.65
3	.161	4.1	.0287	.73	3.22	16	.031	.79	.0075	.19	.56
4	.142	3.6	.0260	.66	2.81	17	.028	.70	.0067	.17	.50
5	.126	3.2	.0232	.59	2.49	18	.024	.62	.0059	.15	.44
6	.110	2.8	.0209	.53	2.16	19	.021	.54	.0055	.14	.37
7	.098	2.5	.0189	.48	1.92	20	.019	.48	.0047	.12	.34
8	.087	2.2	.0169	.43	1.68	21	.017	.42	.0043	.11	.29
9	.075	1.9	.0154	.39	1.43	22	.015	.37	.0039	.10	.25
10	.067	1.7	.0138	.35	1.28	23	.013	.33	.0035	.09	.22
11	.059	1.5	.0122	.31	1.13	24	.011	.29	.0031	.08	.19
12	.051	1.3	.0110	.28	.96	25	.010	.25	.0028	.07	.17

French (Metric) Standard Thread

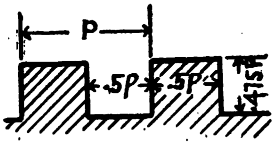


p = pitch f = flat = $\frac{p}{8}$

d = depth = p × .64952

Diameter Mm.	Pitch Mm.	Diameter Mm.	Pitch Mm.	Diameter Mm.	Pitch Mm.
3	0.5	16	2.0	36	2.0
4	0.75	18	2.5	38	4.0
5	0.75	20	2.5	40	4.0
6	1.0	22	2.5	42	4.5
7	1.0	24	3.0	44	4.5
8	1.0	26	3.0	46	4.5
9	1.0	28	3.0	48	5.0
10	1.5	30	3.5	50	5.0
12	1.5	32	3.5	52	5.0
14	2.0	34	3.5	56	5.5

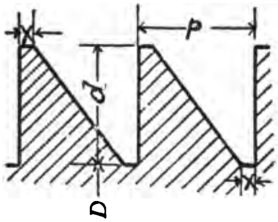
Sellers Square Thread



p = pitch

Dia. Ins.	Threads per in.	Dia. root of thread	Dia. Ins.	Threads per in.	Dia. root of thread	Dia. Ins.	Threads per in.	Dia. root of thread
¼	10	.162	⅝	5½	.466	1	4	.781
5/16	9	.215	11/16	5	.512	1⅛	3½	.875
⅜	8	.265	¾	5	.575	1¼	3½	1.000
7/16	7	.312	13/16	4½	.618	1⅜	3	1.083
½	6½	.365	⅞	4½	.680	1½	3	1.208
9/16	6	.416	15/16	4	.718	1⅝	2¾	1.307

Buttress Thread



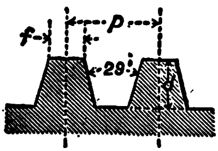
p = pitch

$$d = \frac{\text{root dia. D}}{8}$$

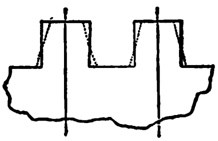
$$x = \frac{p}{8}$$

Buttress thread takes load in one direction.

Acme Thread



Comparison of Acme and Square Threads.



p = pitch
d = depth = .5p + .01 in.

flat top f = .3707p
flat bottom = .3707p − .0052 in.

Number of Threads per In.	Pitch of Single Thread	Depth of Thread	Width at Top of Thread	Width at Bottom of Thread	Space at Top of Thread	Thickness at Root of Thread
1	1.000	.5100	.3707	.3655	.6293	.6345
1⅓	.750	.3850	.2780	.2728	.4720	.4772
2	.500	.2600	.1853	.1801	.3147	.3199
3	.333	.1767	.1235	.1183	.2098	.2150
4	.250	.1350	.0927	.0875	.1573	.1625
5	.200	.1100	.0741	.0689	.1250	.1311
6	.166	.0933	.0618	.0566	.1049	.1101
7	.142	.0814	.0529	.0478	.0899	.0951
8	.125	.0725	.0463	.0411	.0787	.0839
9	.111	.0655	.0413	.0361	.0699	.0751
10	.100	.0600	.0371	.0319	.0629	.0681

S. A. E. Standard Thread

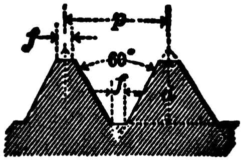
Society of Automotive Engineers (S. A. E.) standard thread has the United States standard form, but has more threads per inch.

$$n = \text{number of threads per inch}$$

$$p = \text{pitch} = \frac{1}{n}$$

$$d = \text{depth} = p \times .6495 = \frac{.6495}{n}$$

$$f = \text{flat} = \frac{p}{8}$$



Diameter Ins.	Decimal Equivalent Outside Diameter	Threads per Inch	Basic Pitch Diameter	Root Diameter	(d) Depth of Thread $\frac{.6495}{n}$
1/4	.250	28	.2269	.2038	.0231
5/16	.3125	24	.2855	.2585	.0270
3/8	.375	24	.3480	.3210	.0270
7/16	.4375	20	.4050	.3725	.0325
1/2	.500	20	.4675	.4350	.0325
9/16	.5625	18	.5264	.4903	.0361
5/8	.625	18	.5889	.5528	.0361
11/16	.6875	16	.6469	.6063	.0406
3/4	.750	16	.7094	.6688	.0406
7/8	.8750	14	.8286	.7822	.0464
7/8	.875	18	.8389	.8028	.0361
1	1.000	14	.9536	.9072	.0464
1 1/8	1.125	12	1.0709	1.0168	.0541
1 1/4	1.250	12	1.1959	1.1418	.0541
1 3/8	1.375	12	1.3209	1.2668	.0541
1 1/2	1.500	12	1.4459	1.3918	.0541

Threads Recommended by National Screw Thread Commission, Washington, D. C.

[1919–1920]

Symbols.—For using formulæ for expressing relations of screw threads and for use on drawings the following list should be used. For definitions see page 58

Major diameter	D
(corresponding radius)	d
Pitch diameter	E
(corresponding radius)	e
Minor diameter	K
(corresponding radius)	k
Angle of thread	A
(One-half angle of thread)	a
Number of turns per inch	N
" " threads " "	n
Lead	$P = \frac{1}{N}$
Pitch or thread interval	$p = \frac{1}{n}$
Helix angle	s
Tangent of helix angle	$S = \frac{P}{3.1416 \times E}$
Width of basic flat at top, crest or root	F
Depth of basic truncation	f
" " sharp V thread	H
" " National (U.S.) form of thread	h
Included angle of taper	Y
(One-half included angle of taper)	y

The basis of the system is the initial letters of the series, preceded by the diameter in inches (or the screw number) and number of threads per inch, all in Arabic characters, followed by the classification of fit in Roman numerals.

Examples	Mark
National Coarse Thread System. To specify a threaded part 1 inch diameter, 8 threads per inch, Class one fit.	1″ — 8 — N C — I
National Fine Thread System. Threaded part 1″ diameter, 14 threads per inch, Class three fit.	1″ — 14 — N F — III

Threads Recommended by National Screw Thread Commission, Washington, D. C.—Continued

[1919–1920]

National Form, Special Pitch. Threaded part 1″ diameter, 12 threads per inch, Class four fit. 1″ — 12 — N — IV

Form of Thread.—The national form of thread profile, known previously as the United States Standard or Sellers' Profile, is recommended by the Commission (National Screw Thread Commission, Washington, D. C.) and shall hereafter be known as the National Form of Thread.

a. Where Used.—The national form shall be used for all screw thread work except when otherwise specified for special purposes.

b. Specifications.—The basic angle of thread (A) between the sides of the thread measured in an axial plane shall be 60 degs. The line bisecting this 60 deg. angle shall be perpendicular to the axis of the screw thread.

The basic flat at the root and crest of the thread form will be $\frac{1}{8} \times p$. The basic depth of the thread form will be $.649519 \times p = \frac{.649519}{n}$

Where p = pitch in inches.
n = number of threads per inch.

c. Clearance in Nut.—(1) Clearance at minor diameter.—A clearance shall be provided at the minor diameter of the nut by removing the thread form at the crest by an amount equal to $\frac{1}{6}$ to $\frac{1}{4}$ of the basic thread depth. (2) Clearance at major diameter.—A clearance at the major diameter of the nut shall be provided by decreasing the depth of the truncation triangle by an amount equal to $\frac{1}{3}$ to $\frac{2}{3}$ of its theoretical value.

Thread Series Recommended.—National Coarse Threads and National Fine Threads. The National Coarse Threads (see Table 1) are recommended for general use in engineering work, in machine construction where conditions are favorable to the use of bolts, screws and other threaded components where quick and easy assembly of the parts is desired, and for all work where conditions do not require the use of fine pitch threads.

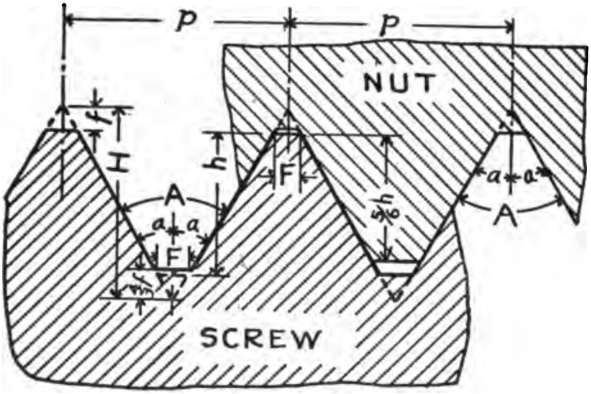
TABLE 1—NATIONAL COARSE THREAD SERIES

Identification		Basic Diameters			Thread Data		
1	2	3	4	5	6	7	8
Numbered and Fractional Sizes	n Number of Threads per In.	D Major Dia. In.	E Pitch Dia. In.	K Minor Dia. In.	Metric Equivalent of Major Dia. Mm.	p Pitch In.	h Depth of Thread In.
1	64	0.073	0.0629	0.0527	1.854	0.0156250	0.0101
2	56	0.086	0.0744	0.0628	2.184	0.0178572	0.0116
3	48	0.099	0.0855	0.0719	2.515	0.0208333	0.0135
4	40	0.112	0.0958	0.0795	2.845	0.0250000	0.0162
5	40	0.125	0.1088	0.0925	3.175	0.0250000	0.0162
6	32	0.138	0.1177	0.0974	3.505	0.0312500	0.0203
8	32	0.164	0.1437	0.1234	4.156	0.0312500	0.0203
10	24	0.190	0.1629	0.1359	4.826	0.0416667	0.0271
12	24	0.216	0.1889	0.1619	5.486	0.0416667	0.0271
1/4	20	0.2500	0.2175	0.1850	6.350	0.0500000	0.0325
5/16	18	0.3125	0.2764	0.2403	7.938	0.0555556	0.0361
3/8	16	0.3750	0.3344	0.2938	9.525	0.0625000	0.0406
7/16	14	0.4375	0.3911	0.3447	11.11	0.0714286	0.0464
1/2	13	0.5000	0.4500	0.4001	12.69	0.0769231	0.0500
9/16	12	0.5625	0.5084	0.4542	14.29	0.0833333	0.0541
5/8	11	0.6250	0.5659	0.5069	15.88	0.0909091	0.0590
3/4	10	0.7500	0.6850	0.6201	19.05	0.1000000	0.0650
7/8	9	0.8750	0.8028	0.7307	22.22	0.1111111	0.0722
1	8	1.0000	0.9188	0.8376	25.40	0.1250000	0.0812
1 1/8	7	1.1250	1.0322	0.9394	28.58	0.1428572	0.0928
1 1/4	7	1.2500	1.1572	1.0644	31.75	0.1428572	0.0928
1 1/2	6	1.5000	1.3917	1.2835	38.10	0.1666667	0.1083
1 3/4	5	1.7500	1.6201	1.4902	44.45	0.2000000	0.0299
2	4 1/2	2.0000	1.8557	1.7113	50.80	0.2222222	0.1443
2 1/4	4 1/2	2.2500	2.1057	1.9613	57.15	0.2222222	0.1443
2 1/2	4	2.5000	2.3376	2.1752	63.50	0.2500000	0.1624
2 3/4	4	2.7500	2.5876	2.4252	69.85	0.2500000	0.1624
3	4	3.0000	2.8376	2.6752	76.20	0.2500000	0.1624

The National Fine Threads (see Table 2) are recommended for general use in automotive and aircraft work, for use where the de-

sign requires both strength and reduction in weight, and where special conditions require a fine thread, as for instance, on large sizes where sufficient force cannot be secured to set properly a screw or bolt of coarse pitch, by exerting on an ordinary wrench the strength of a man. The form of thread for coarse and fine threads is the same as outlined in the paragraph Form of Thread.

National Form of Thread for Minimum Nut and Maximum Screws



In the figure no allowance is shown. This condition exists in Class II. Medium Fit where both the minimum nut and the maximum screw are basic.

Notation

A	$= 60°$	Angle of thread.
a	$= 30°$	One-half angle of thread.
p	$= \frac{1}{n}$	Pitch
n	=	Number of threads per inch.
H	$= .866025p$	Depth of 60° sharp V thread.
h	$= .649519p$	" " standard form thread.
$^5/_6h$	$= .541266p$	
F	$= .125000p$	Width of flat at crest and root of standard form.
f	$= .108253p$	
	$= {}^1/_8\,H$	
	$= {}^1/_6\,h$	Depth of truncation.

TABLE 2—NATIONAL FINE THREAD SERIES

Identification		Basic Diameters			Thread Data		
1	2	3	4	5	6	7	8
Numbered and Fractional Sizes	n Number of Threads per In.	D Major Dia. In.	E Pitch Dia. In.	K Minor Dia. In.	Metric Equivalent of Major Dia. Mm.	p Pitch In.	h Depth of Thread In.
0	80	0.060	0.0519	0.0438	1.524	0.0125000	0.00812
1	72	0.073	0.0640	0.0550	1.854	0.0138889	0.00902
2	64	0.086	0.0759	0.0657	2.184	0.0156250	0.01014
3	56	0.099	0.0874	0.0758	2.515	0.0178571	0.01160
4	48	0.112	0.0985	0.0849	2.845	0.0208333	0.01353
5	44	0.125	0.1102	0.0955	3.175	0.0227273	0.01476
6	40	0.138	0.1218	0.1055	3.506	0.0250000	0.01624
8	36	0.164	0.1460	0.1279	4.166	0.0277778	0.01804
10	32	0.190	0.1697	0.1494	4.826	0.0312500	0.02030
12	28	0.216	0.1928	0.1696	5.486	0.0357143	0.02319
1/4	28	0.250	0.2268	0.2036	6.350	0.0357143	0.02319
5/16	24	0.3125	0.2854	0.2584	7.938	0.0416667	0.02706
3/8	24	0.3750	0.3479	0.3209	9.525	0.0416667	0.02706
7/16	20	0.4375	0.4050	0.3726	11.11	0.0500000	0.03248
1/2	20	0.5000	0.4675	0.4350	12.70	0.0500000	0.03248
9/16	18	0.5625	0.5264	0.4903	14.29	0.0555556	0.03608
5/8	18	0.6250	0.5889	0.5528	15.88	0.0555556	0.03608
3/4	16	0.7500	0.7094	0.6688	19.05	0.0625000	0.04060
7/8	14	0.8750	0.8286	0.7822	22.22	0.0714286	0.04640
1	14	1.0000	0.9536	0.9072	25.40	0.0714286	0.04640
1 1/8	12	1.1250	1.0709	1.0168	28.57	0.0833333	0.05413
1 1/4	12	1.2500	1.1959	1.1418	31.75	0.0833333	0.05413
1 1/2	12	1.5000	1.4459	1.3918	38.10	0.6833333	0.05413
1 3/4	12	1.7500	1.6959	1.6418	44.45	0.0833333	0.05413
2	12	2.0000	1.9459	1.8918	50.80	0.0833333	0.05413
2 1/4	12	2.2500	2.1959	2.1418	57.15	0.0833333	0.05413
2 1/2	12	2.5000	2.4459	2.3918	63.50	0.0833333	0.05413
2 3/4	12	2.7500	2.6959	2.6418	69.85	0.0833333	0.05413
3	10	3.0000	2.9350	2.8701	76.20	0.1000000	0.06495

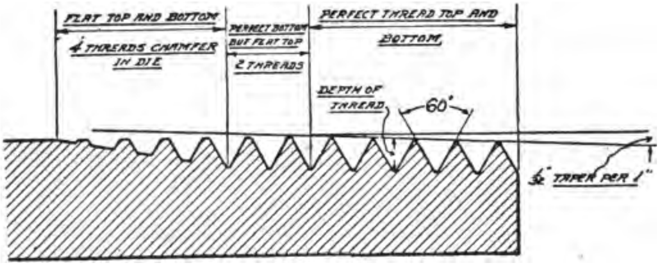
Classification of Fits.

Class I Loose fit		Includes screw thread work of rough commercial quality, such as hose couplings, etc.
Class II Medium fit	Subdivision "A" (Regular)	Includes the great bulk of screw thread work of ordinary quality of finished and semi-finished bolts and nuts, machine screws, etc.
	Subdivision "B" (Special)	Includes the better grade of interchangeable screw thread work, such as high grade automobile and aircraft bolts and nuts.
Class III Close fit		Includes screw thread work requiring a fine snug fit, somewhat closer than the medium fit special. In this class of fit selective assembly of parts may be required.
Class IV Wrench fit	Subdivision "A"	Includes screw threads used in light sections with moderate stresses, such as aircraft and automobile engine work.
	Subdivision "B"	Includes screw threads used in heavy sections with heavy stresses, such as steam engine and heavy hydraulic work.

PIPE THREADS

The standard in the United States is the Briggs, and in Great Britain is the Whitworth. In Briggs, the pipe is tapered 1/16 in. per in.

Briggs Pipe Threads

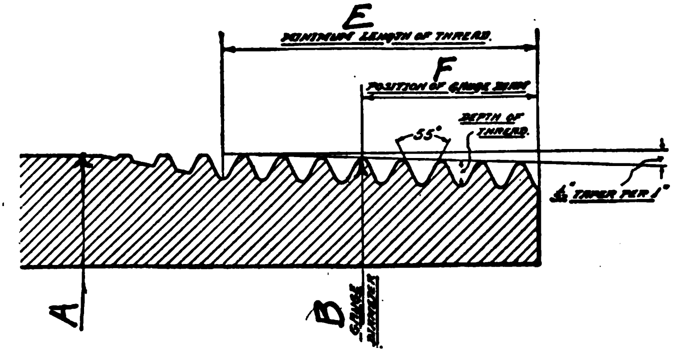


N = number of threads per inch. Depth of thread = $\frac{.8}{N}$

Length of perfect thread = $\frac{.8D + 4.8}{N}$ where D represents the actual outside diameter of pipe.

Pipe Diameters			Threads per Inch	Depth of Thread	Length of Perfect Threads	Total Length of Thread on Pipe
Nominal Pipe Size	Actual Inside	Actual Outside				
⅛	.270	.405	27	.029	.19	.412
¼	.364	.540	18	.044	.29	.624
⅜	.494	.675	18	.044	.30	.630
½	.623	.840	14	.057	.39	.819
¾	.824	1.050	14	.057	.40	.831
1	1.048	1.315	11½	.069	.51	1.03
1¼	1.380	1.660	11½	.069	.54	1.06
1½	1.610	1.900	11½	.069	.55	1.07
2	2.067	2.375	11½	.069	.58	1.10
2½	2.468	2.875	8	.100	.89	1.64
3	3.067	3.500	8	.100	.95	1.70
3½	3.548	4.000	8	.100	1.00	1.75
4	4.026	4.500	8	.100	1.05	1.80
4½	4.508	5.000	8	.100	1.10	1.85
5	5.045	5.563	8	.100	1.16	1.91
6	6.065	6.625	8	.100	1.26	2.01
7	7.023	7.625	8	.100	1.36	2.11
8	7.982	8.625	8	.100	1.46	2.21
9	9.000	9.625	8	.100	1.57	2.32
10	10.019	10.750	8	.100	1.68	2.43

Whitworth or British Standard Pipe Threads



N = number of threads per inch. Depth of thread $= \frac{.64}{N}$

	A	B			E	F
Nominal Bore of Pipe Ins.	Approx. Outside Dia. of Pipe Ins.	Gauge Dia. Top of Thread Ins.	Single Depth of Thread Ins.	Number of Threads per Inch	Length of Thread on Pipe Ins.	Dist. of Gauge Dia. from End of Pipe Ins.
1/8	13/32	.383	.0230	28	3/8	5/32
1/4	17/32	.518	.0335	19	7/16	3/16
3/8	11/16	.656	.0335	19	1/2	1/4
1/2	27/32	.825	.0455	14	5/8	1/4
5/8	15/16	.902	.0455	14	5/8	1/4
3/4	1 1/16	1.041	.0455	14	3/4	3/8
7/8	1 7/32	1.189	.0455	14	3/4	3/8
1	1 11/32	1.309	.0580	11	7/8	3/8
1 1/4	1 11/16	1.650	.0580	11	1	1/2
1 1/2	1 29/32	1.882	.0580	11	1	1/2
1 3/4	2 5/32	2.116	.0580	11	1 1/8	5/8
2	2 3/8	2.347	.0580	11	1 1/8	5/8
2 1/4	2 5/8	2.587	.0580	11	1 1/4	11/16
2 1/2	3	2.960	.0580	11	1 1/4	11/16
2 3/4	3 1/4	3.210	.0580	11	1 3/8	13/16
3	3 1/2	3.460	.0580	11	1 3/8	13/16
3 1/4	3 3/4	3.700	.0580	11	1 1/2	7/8
3 1/2	4	3.950	.0580	11	1 1/2	7/8
3 3/4	4 1/4	4.200	.0580	11	1 1/2	7/8

(Continued on page 74)

Whitworth or British Standard Pipe Threads—Continued

Nominal Bore of Pipe Ins.	A	B			E	F
	Approx. Outside Dia. of Pipe Ins.	Gauge Dia. Top of Thread Ins.	Single Depth of Thread In.	Number of Threads per In.	Length of Thread on Pipe Ins.	Dist. of Gauge Dia. from End of Pipe Ins.
4	4½	4.450	.0580	11	1⅝	1
4½	5	4.950	.0580	11	1⅝	1
5	5½	5.450	.0580	11	1¾	1⅛
5½	6	5.950	.0580	11	1⅞	1¼
6	6½	6.450	.0580	11	2	1⅜
7	7½	7.450	.0640	10	2⅛	1⅜
8	8½	8.450	.0640	10	2¼	1½
9	9½	9.450	.0640	10	2¼	1½
10	10½	10.450	.0640	10	2⅜	1⅝
11	11½	11.450	.0800	8	2½	1⅝
12	12½	12.450	.0800	8	2½	1⅝
13	13¾	13.680	.0800	8	2⅝	1⅝
14	14¾	14.680	.0800	8	2¾	1¾
15	15¾	15.680	.0800	8	2¾	1¾
16	16¾	16.680	.0800	8	2⅞	1⅞
17	17¾	17.680	.0800	8	3	2
18	18¾	18.680	.0800	8	3	2

Threads for Pipe and Fire Hose Couplings Recommended by National Screw Thread Commission, Washington, D. C., 1919–1920

The Commission favored the adoption in practically its present shape of the Briggs standard pipe thread size as recommended by the Am. Society of Mechanical Engineers and the fire hose coupling as established by National Fire Protective Association.

National Pipe Threads

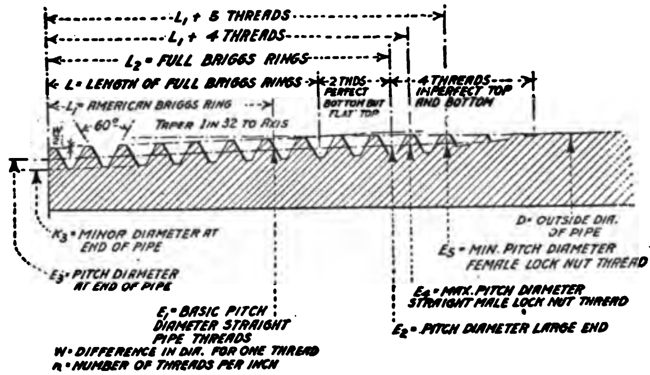
Formulæ for Basic Size. (See Table 3, page 76)

$$L = \frac{0.8D + 4.8}{n} \qquad E_3 = K_3 + \frac{0.8}{n}$$

$$K_3 = D = \frac{0.05D + 1.9}{n} \qquad E_2 = E_3 + \frac{L_2}{16}$$

$$E_1 = E_3 + \frac{L_1}{16} \qquad w = \frac{1}{16\,n}$$

$$L_2 = L + 2\left(\frac{1}{n}\right)$$



National Fire Hose Coupling Threads. Form of Thread, see page 67.

National Fire Hose Couplings

Basic Min. Coupling Dimensions

Nominal Size	Number of threads per inch	Pitch	Depth of Thread	Major diameter		Pitch dia.	Minor dia.	Allowance
		Ins.	Ins.	Mm.	Ins.	Ins.	Ins.	Ins.
2.50	7.5	.13333	.0955	78.550	3.0925	2.9970	2.9015	.03
3.00	6.0	.16667	.1243	92.837	3.6550	3.5307	3.4063	.03
3.50	6.0	.16667	.1243	108.712	4.2800	4.1556	4.0313	.03
4.50	4.0	.25000	.1765	147.320	5.8000	5.6235	5.4470	.05

Basic Max. Nipple Dimensions

2.50	7.5	.13333	.0955	77.788	3.0625	2.9670	2.8715	.03
3.00	6.0	.16667	.1243	92.075	3.6250	3.5006	3.3763	.03
3.50	6.0	.16667	.1243	107.950	4.2500	4.1256	4.0013	.03
4.50	4.0	.25000	.1765	146.050	5.7500	5.5735	5.3970	.05

TABLE 3—NATIONAL PIPE THREAD SERIES—TAPER, STRAIGHT PIPE THREAD AND LOCK NUT SIZES AND BASIC DIMENSIONS

Pipe Size in In.	Threads per In.	Depth of Thread	Pitch Dia. at End of Pipe	Pitch Dia. at Gauge Notch Basic Straight	Max. Pitch Dia. Straight Male Lock Nut Thread	Min. Pitch Dia. Straight Female Lock Nut Thread	Outside Dia. of Pipe	Thickness Full Briggs Ring	Inches Thickness American Briggs Ring	Pitch Dia. at Large End	Difference in Dia. for One Thread
	n	0.8n	E_3	E_1	E_4	E_5	D	L_4	L_1	E_2	w
1/8	27	0.0296	0.3635	0.3748	0.3840	0.3863	0.405	0.2638	0.180	0.3800	0.00232
1/4	18	0.0444	0.4774	0.4899	0.5038	0.5073	0.540	0.4018	0.200	0.6025	0.00347
3/8	18	0.0444	0.6120	0.6270	0.6410	0.6444	0.675	0.4078	0.240	0.6375	0.00347
1/2	14	0.0571	0.7584	0.7784	0.7963	0.8008	0.840	0.5337	0.320	0.7918	0.00446
3/4	14	0.0571	0.9677	0.9888	1.0067	1.0112	1.050	0.5457	0.339	1.0018	0.00446
1	11½	0.0696	1.2136	1.2386	1.2604	1.2658	1.315	0.6828	0.400	1.2563	0.00543
1¼	11½	0.0696	1.5571	1.5834	1.6051	1.6106	1.660	0.7068	0.420	1.6013	0.00543
1½	11½	0.0696	1.7961	1.8223	1.8441	1.8495	1.900	0.7235	0.420	1.8413	0.00543
2	11½	0.0696	2.2690	2.2963	2.3180	2.3234	2.375	0.7565	0.436	2.3163	0.00543
2½	8	0.1000	2.7195	2.7622	2.7934	2.8012	2.875	1.1375	0.682	2.7906	0.00781
3	8	0.1000	3.3406	3.3885	3.4198	3.4276	3.500	1.2000	0.766	3.4156	0.00781
3½	8	0.1000	3.8375	3.8888	3.9201	3.9279	4.000	1.2500	0.821	3.9156	0.00781
4	8	0.1000	4.3344	4.3871	4.4184	4.4262	4.500	1.3000	0.844	4.4156	0.00781
4½	8	0.1000	4.8212	4.8859	4.9172	4.9250	5.000	1.3500	0.875	4.9156	0.00781
5	8	0.1000	5.3907	5.4493	5.4806	5.4884	5.563	1.4063	0.937	5.4786	0.00781
6	8	0.1000	6.4460	6.5060	6.5372	6.5450	6.625	1.5125	0.958	6.5406	0.00781
7	8	0.1000	7.4400	7.5020	7.5340	7.5410	7.625	1.6120	1.000	7.5410	0.00781
8	8	0.1000	8.4340	8.5000	8.5310	8.5390	8.625	1.7120	1.063	8.5410	0.00781
9	8	0.1000	9.4270	9.4980	9.5290	9.5370	9.625	1.8120	1.130	9.5410	0.00781
10	8	0.1000	10.5450	10.6210	10.6520	10.6600	10.750	1.9250	1.210	10.6660	0.00781
12	8	0.1000	12.5340	12.6190	12.6500	12.6580	12.750	2.1250	1.360	12.6670	0.00781
14	8	0.1000	13.7750	13.8730	13.9040	13.9120	14.000	2.2500	1.562	13.9160	0.00781
15	8	0.1000	14.7690	14.8740	14.9050	14.9540	15.000	2.3500	1.687	14.9160	0.00781
16	8	0.1000	15.7620	15.8760	15.9060	15.9150	16.000	2.4500	1.812	15.9160	0.00781
18	8	0.1000	17.7500	17.8750	17.9060	17.9140	18.000	2.6500	2.000	17.9160	0.00781
20	8	0.1000	19.7380	19.8700	19.9020	19.9100	20.000	2.8500	2.125	19.9160	0.00781
22	8	0.1000	21.7250	21.8660	21.8970	21.9050	22.000	3.0500	2.250	21.9160	0.00781
24	8	0.1000	23.7120	23.8610	23.8920	23.9000	24.000	3.2500	2.375	23.9160	0.00781

TAP DRILLS

For Standard Pitch Threads

Thread Diameter	U. S. S. Threads per Inch	U. S. S. Tap Drill Size	Whitworth Threads per Inch	Whitworth Tap Drill Size	S. A. E. Threads per Inch	S. A. E. Tap Drill Size	Thread Diameter	U. S. S. Threads per Inch	U. S. S. Tap Drill Size	Whitworth Threads per Inch	Whitworth Tap Drill Size
3/32	50	.....	48	.....	.....	.....	1 3/4	5	1 35/64	5	1 9/16
1/8	40	.....	40	.....	.....	.....	1 7/8	5	1 43/64	4 1/2	
3/16	32	.....	24	.....	.....	.....	2	4 1/2	1 25/32	4 1/2	1 25/32
1/4	20	13/64	20	13/64	28	No. 2	2 1/8	4 1/2	1 29/32	4 1/2	
5/16	18	1/4	18	.....	24	17/64	2 1/4	4 1/2	2 1/32	4	
3/8	16	5/16	16	.....	24	21/64	2 3/8	4	2 1/8	4	
7/16	14	23/64	14	.....	20	25/64	2 1/2	4	2 1/4	4	
1/2	13	27/64	12	27/64	20	29/64	2 5/8	4	2 13/32	4	
9/16	12	15/32	12	31/64	20	1/2	2 3/4	4	2 1/2	3 1/2	
5/8	11	17/32	11	35/64	18	37/64	2 7/8	3 1/2	2 19/32	3 1/2	
11/16	11	19/32	11	39/64	16	5/8	3	3 1/2	2 23/32	3 1/2	
3/4	10	41/64	10	21/32	16	11/16	3 1/8	3 1/2	2 27/32	3 1/2	
13/16	10	45/64	10	23/32	.....	3/4	3 1/4	3 1/2	2 31/32	3 1/4	
7/8	9	49/64	9	25/32	14	13/16	3 3/8	3 1/4	3 1/16	3 1/4	
15/16	9	53/64	9	.....	.....	7/8	3 1/2	3 1/4	3 3/16	3 1/4	
1	8	7/8	8	7/8	14	15/16	3 5/8	3 1/4	3 5/16	3 1/4	
1 1/8	7	63/64	7	1	12	1 3/64	3 3/4	3	3 7/64	3	
1 1/4	7	1 7/64	7	1 1/8	12	1 11/64	3 7/8	3	3 35/64	3	
1 3/8	6	1 7/32	6	1 7/32	12	1 19/64	4	3	3 43/64	3	
1 1/2	6	1 11/32	6	1 11/32	12	1 27/64	4 1/4	2 7/8	3 29/32	2 7/8	
1 5/8	5 1/2	1 7/16	5	1 7/16	.....	.....	4 1/2	2 3/4	4 9/64	2 7/8	

Above Tap Drill Sizes are computed to allow approximately 75% of full thread.

NAILS

Wire nails have a circular cross section, the steel wire gauge is used for designating their diameter. The length is given in the penny system, the letter d being the selected symbol, thus a

2	penny	nail	(2 d)	is	1″	long
3	"	"	(3 d)	"	1 1/4″	"
4	"	"	(4 d)	"	1 1/2″	"
5	"	"	(5 d)	"	1 3/4″	"

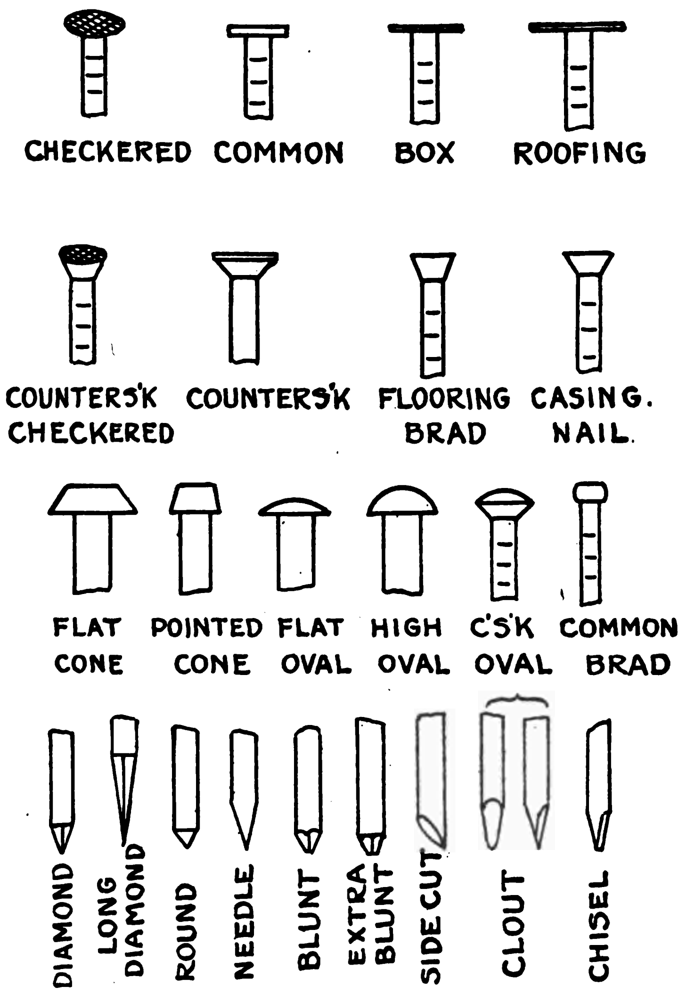
etc.

Cut nails have a rectangular cross section, with taper from head to point.

A keg of nails weighs 100 lbs.

Cement coated nails have practically twice the holding power of common wire nails. Cement coated nails (as manufactured by Wickwire Bros., Cortland, N. Y.) are like common nails except in the style of head.

NAIL HEADS AND POINTS



Common Nails

Size	Length	Steel Wire Gauge	Approx. No. to Lb.
2d	1 inch	No. 15	876
3d	1¼ "	" 14	568
4d	1½ "	" 12½	316
5d	1¾ "	" 12½	271
6d	2 "	" 11½	181
7d	2¼ "	" 11½	161
8d	2½ "	" 10¼	106
9d	2¾ "	" 10¼	96
10d	3 "	" 9	69
12d	3¼ "	" 9	63
16d	3½ "	" 8	49
20d	4 "	" 6	31
30d	4½ "	" 5	24
40d	5 "	" 4	18
50d	5½ "	" 3	14
60d	6 "	" 2	11

Common Brads

Size	Length	Steel Wire Gauge	Approx. No. to Lb.
2d	1 inch	No. 15	876
3d	1¼ "	" 14	568
4d	1½ "	" 12½	316
5d	1¾ "	" 12½	271
6d	2 "	" 11½	181
7d	2¼ "	" 11½	161
8d	2½ "	" 10¼	106
9d	2¾ "	" 10¼	96
10d	3 "	" 9	69
12d	3¼ "	" 9	64
16d	3½ "	" 8	49
20d	4 "	" 6	31
30d	4½ "	" 5	24
40d	5 "	" 4	18
50d	5½ "	" 3	16
60d	6 "	" 2	11

Flooring Brads

Sizes 6d, 7d, 8d, 9d, 10d, 12d, 16d and 20d have the same length as common brads but average one gauge lighter.

Clinch Nails
(Flat Oval Head)

Size	Length	Steel Wire Gauge	Approx. No. to Lb.
2d	1 inch	No. 14	710
3d	1¼ "	" 13	429
4d	1½ "	" 12	274
5d	1¾ "	" 12	235
6d	2 "	" 11	157
7d	2¼ "	" 11	139
8d	2½ "	" 10	99
9d	2¾ "	" 10	90
10d	3 "	" 9	69
12d	3¼ "	" 9	62
16d	3½ "	" 8	49
20d	4 "	" 7	37

Casing Nails

Size	Length	Steel Wire Gauge	Approx. No. to Lb.
2d	1 inch	No. 15½	1010
3d	1¼ "	" 14½	635
4d	1½ "	" 14	473
5d	1¾ "	" 14	406
6d	2 "	" 12½	236
7d	2¼ "	" 12½	210
8d	2½ "	" 11½	145
9d	2¾ "	" 11½	132
10d	3 "	" 10½	94
12d	3¼ "	" 10½	87
16d	3½ "	" 10	71
20d	4 "	" 9	62
30d	4½ "	" 9	46
40d	5 "	" 8	35

Roofing Nails

Size	No. 8	No. 9	No. 9½	No. 10
Dia. of head, ins.	½	½	½	7/16 & ½

Lengths, all sizes, ¾, ⅞, 1, 1⅛, 1¼, 1½, 1¾ ins.

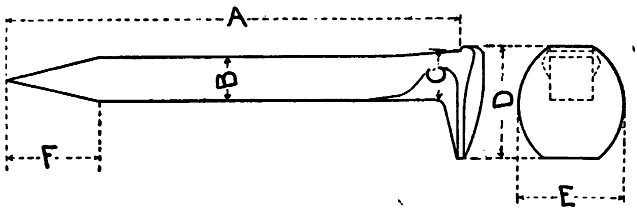
[Wickwire Bros., Cortland, N. Y.]

SPIKES

Square

Railroad Spikes

A standard railroad spike has a square cross section with a chisel point as in figure below. Reverse point has the cutting edge parallel to the length of the head—this type of spike is often used on bridge stringers, where the stringers run parallel to the track.



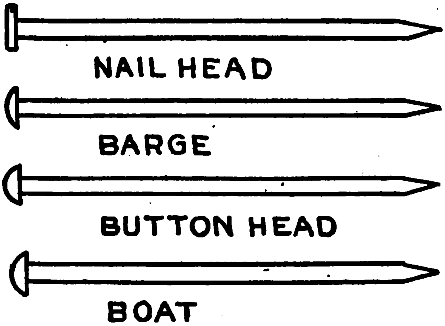
Length A	Thickness of shank B	Thickness of neck C	Head: Length D	Head: Width E	Length of taper F	Approx. number per keg of 200 lbs.
2½	5/16	5/16	¾	⅝	⅝	2200
2½	⅜	⅜	1	¾	¾	1520
3	⅜	⅜	1	¾	¾	1340
3½	⅜	⅜	1	¾	¾	1170
4	7/16	7/16	1⅛	⅞	⅞	684
3½	½	9/16	1¼	1 1/16	⅞	620
4	½	9/16	1¼	1 1/16	1	600
4½	½	9/16	1¼	1 1/16	1	536
5	½	9/16	1¼	1 1/16	1	490
5	9/16	⅝	1 7/16	1¼	1⅛	370
5½	9/16	⅝	1 7/16	1¼	1⅛	340
6	⅝	¾	1 9/16	1⅜	1¼	269

[Illinois Steel Co., Chicago, Ill.]

Spikes are made of Bessemer or open hearth steel having the following properties: Tensile strength, 55,000 lb. per sq. in.; yield point, 27,500 lb. per sq. in.; elongation, 25 per cent in 2 ins. The body of the full-size finished spike shall bend cold through 180 degs.

flat on itself, without cracking on the outside portion. The head of the full-size finished spike shall bend backward to the line of the face of the spike, without cracking on the outside of the bent portion.

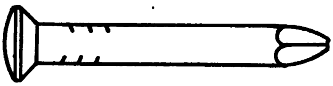
Nail, Barge, Button and Boat Head Spikes



(Approximate number per keg of 200 lb.)

Inches Square	Length of Spike—Inches											
	3	4	5	6	7	8	9	10	11	12	14	16
5/8	.....	.....	.....	.....	.....	260	240	220	205	190	175	160
1/2	.....	.....	.....	450	375	335	300	275	260	240	.....	.....
7/16	.....	.....	.....	600	590	510	400	360	320	230	.....	.....
3/8	1320	1140	940	800	650	600	525	475	.....	.....	.....	.....
5/16	1660	1360	1230	1175	990	880	.....	.....	.....	.....	.....	.....
1/4	3000	2375	2050	1825	.....	.....	.....	.....	.....	.....	.....	.....

Round



These can be obtained with chisel or diamond points and with flat heads.

ROUND—*Continued*

Size	Length	Am. Steel Wire Gauge	Approx. No. to Lb.
10d	3 inch	No. 6	41
12d	3 1/4 "	" 6	38
16d	3 1/2 "	" 5	30
20d	4 "	" 4	23
30d	4 1/2 "	" 3	17
40d	5 "	" 2	13
50d	5 1/2 "	" 1	10
60d	6 "	" 1	8
7 inch	7 "	" 0	7
8 "	8 "	" 00	6
9 "	9 "	" 00	5
10 "	10 "	3/8 inch	4
12 "	12 "	3/8 "	3

KEYS

FOR SHAFTS, GEARS, PULLEYS AND COUPLINGS

Dia. of Shaft	Size of Key	Dia. of Shaft	Size of Key	Dia. of Shaft	Size of Key
In.	In.	In.	In.	In.	In.
1 3/16	7/32 x 7/32	3	11/16 x 11/16	7 1/2	1 1/16 x 1 1/16
1 1/4	7/32 x 7/32	3 1/8	11/16 x 11/16	7 15/16	1 3/16 x 1 3/16
1 3/8	7/32 x 7/32	3 3/16	11/16 x 11/16	8	1 3/16 x 1 3/16
1 7/16	5/16 x 5/16	3 1/4	11/16 x 11/16	8 7/16	1 3/16 x 1 3/16
1 1/2	5/16 x 5/16	3 3/8	11/16 x 11/16	8 1/2	1 3/16 x 1 3/16
1 5/8	5/16 x 5/16	3 7/16	11/16 x 11/16	8 15/16	1 5/16 x 1 5/16
1 11/16	7/16 x 7/16	3 1/2	11/16 x 11/16	9	1 5/16 x 1 5/16
1 3/4	7/16 x 7/16	3 15/16	13/16 x 13/16	9 7/16	1 5/16 x 1 5/16
1 7/8	7/16 x 7/16	4	13/16 x 13/16	9 1/2	1 5/16 x 1 5/16
1 15/16	7/16 x 7/16	4 7/16	13/16 x 13/16	9 15/16	1 7/16 x 1 7/16
2	7/16 x 7/16	4 1/2	13/16 x 13/16	10	1 7/16 x 1 7/16
2 1/8	7/16 x 7/16	4 15/16	13/16 x 13/16	10 7/16	1 7/16 x 1 7/16
2 3/16	9/16 x 9/16	5	13/16 x 13/16	10 1/2	1 7/16 x 1 7/16
2 1/4	9/16 x 9/16	5 7/16	13/16 x 13/16	10 15/16	1 11/16 x 1 11/16
2 3/8	9/16 x 9/16	5 1/2	13/16 x 13/16	11	1 11/16 x 1 11/16
2 7/16	9/16 x 9/16	5 15/16	15/16 x 15/16	11 7/16	1 11/16 x 1 11/16
2 1/2	9/16 x 9/16	6	15/16 x 15/16	11 1/2	1 11/16 x 1 11/16
2 5/8	9/16 x 9/16	6 7/16	15/16 x 15/16	11 15/16	2 x 2
2 11/16	11/16 x 11/16	6 1/2	15/16 x 15/16	12	2 x 2
2 3/4	11/16 x 11/16	6 15/16	1 1/16 x 1 1/16	12 7/16	2 x 2
2 7/8	11/16 x 11/16	7	1 1/16 x 1 1/16	12 1/2	2 x 2
2 15/16	11/16 x 11/16	7 7/16	1 1/16 x 1 1/16		

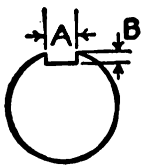
[Cresson-Morris Co., Phila., Pa.]

Special Keys for Heavy Machinery

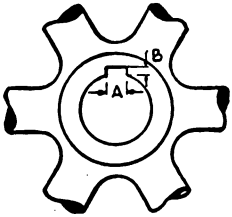
Dia. of Shaft	Size of Key	Dia. of Shaft	Size of Key	Dia. of Shaft	Size of Key
In.	In.	In.	In.	In.	In.
2 15/16	7/8 x 5/8	4 15/16	1 1/4 x 7/8	7 1/2	1 3/4 x 1 1/4
3	7/8 x 5/8	5	1 1/4 x 7/8	7 15/16	2 x 1 3/8
3 1/8	7/8 x 5/8	5 7/16	1 1/4 x 7/8	8	2 x 1 3/8
3 3/16	7/8 x 5/8	5 1/2	1 1/4 x 7/8	8 7/16	2 x 1 3/8
3 1/4	7/8 x 5/8	5 15/16	1 1/2 x 1	8 1/2	2 x 1 3/8
3 7/16	7/8 x 5/8	6	1 1/2 x 1	8 15/16	2 1/4 x 1 1/2
3 1/2	7/8 x 5/8	6 7/16	1 1/2 x 1	9	2 1/4 x 1 1/2
3 15/16	1 x 3/4	6 1/2	1 1/2 x 1	9 7/16	2 1/4 x 1 1/2
4	1 x 3/4	6 15/16	1 3/4 x 1 1/4	9 1/2	2 1/4 x 1 1/2
4 7/16	1 x 3/4	7	1 3/4 x 1 1/4	9 15/16	2 1/4 x 1 1/2
4 1/2	1 x 3/4	7 7/16	1 3/4 x 1 1/4	10	2 1/4 x 1 1/2

[Cresson-Morris Co., Phila., Pa.]

Key Seats in Shafts and Wheels



For Shafts



For Wheels

Diameter of Shaft	Key-way		Diameter of Shaft	Key-way		Diameter of Shaft	Key-way	
	A Width	B Depth		A Width	B Depth		A Width	B Depth
15/16 to 1 1/4	1/4	1/8	5 13/16 to 6 1/4	1 1/2	3/4	14 5/16 to 15 1/4	3 3/4	1
1 5/16 to 1 3/4	3/8	3/16	6 5/16 to 7 1/4	1 3/4	3/4	15 5/16 to 16 1/4	4	1
1 13/16 to 2 1/4	1/2	1/4	7 5/16 to 7 15/16	2	3/4	16 5/16 to 17 1/4	4 1/4	1 1/4
2 5/16 to 2 3/4	5/8	5/16	8 to 8 1/4	2	3/4	17 5/16 to 18 1/4	4 1/2	1 1/4
2 13/16 to 3 1/4	3/4	3/8	8 5/16 to 9 1/4	2 1/4	7/8	18 5/16 to 19 1/4	4 3/4	1 1/4
3 5/16 to 3 3/4	7/8	7/16	9 5/16 to 10 1/4	2 1/2	7/8	19 5/16 to 20 1/4	5	1 1/4
3 13/16 to 4 1/4	1	1/2	10 5/16 to 11 1/4	2 3/4	7/8	20 5/16 to 21 1/4	5 1/4	1 1/2
4 5/16 to 4 3/4	1 1/8	9/16	11 5/16 to 12 1/4	3	7/8	21 5/16 to 22 1/4	5 1/2	1 1/2
4 13/16 to 5 1/4	1 1/4	5/8	12 5/16 to 13 1/4	3 1/4	1	22 5/16 to 23 1/4	5 3/4	1 1/2
5 5/16 to 5 3/4	1 3/8	11/16	13 5/16 to 14 1/4	3 1/2	1	23 5/16 to 24 1/4	6	1 1/2

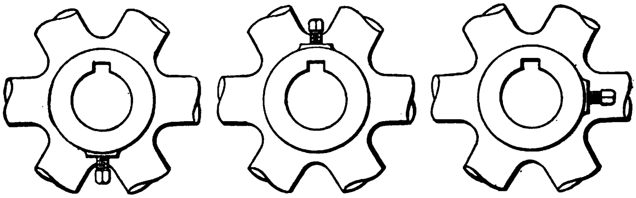
[Dodge Sales & Eng'g Co., Mishawaka, Ind.]

Notes on Keys and Key Seats

On pulleys and gears the key seat is under an arm on all sizes up to 74 ins. dia., when practical with a set screw over the keyway. Large pulleys and gears having 8 arms, when made in two parts have the key seat in the center of one half, that is between two arms.

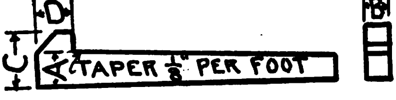
The following represents practice at Gisholt Machine Co., Madison, Wis. For shafts up to $1\frac{13}{16}''$ dia., Woodruff keys. Sliding parts for shafts up to $1\frac{13}{16}''$ dia. square keys and over this diameter flat keys. For hollow shafts and sleeves not transmitting their full power, use a key for a shaft of ½ the diameter of the hollow shaft or sleeve. If full power is transmitted use if possible the standard key for solid shafts, if this is not possible then 2 keys for a shaft of ½ the diameter of the sleeve.

POSITION OF SET-SCREWS FROM KEYWAY



Key seats as left milled by cutters are measured from the bottom of the key seats. Key seats with drilled or square ends are measured from the ends.

Gib Head Keys

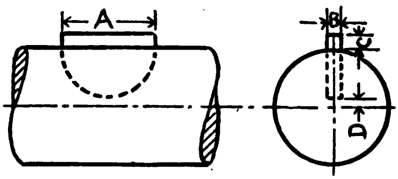


Gib head keys are used when the small end of the key is inaccess-

ible; with the exception of the head they are the same as tapered keys.

A	B	C	D	A	B	C	D
1/8	1/8	1/4	7/32	1 5/8	1 5/8	2 3/4	1 7/8
3/16	3/16	5/16	9/32	1 11/16	1 11/16	2 7/8	1 15/16
1/4	1/4	15/32	11/32	1 3/4	1 3/4	3	2
5/16	5/16	9/16	13/32	1 13/16	1 13/16	3 1/8	2 1/16
3/8	3/8	11/16	15/32	1 7/8	1 7/8	3 3/8	2 1/8
7/16	7/16	3/4	17/32	1 15/16	1 15/16	3 5/8	2 3/16
1/2	1/2	7/8	19/32	2	2	3 3/4	2 1/4
9/16	9/16	1	21/32	2 1/16	2 1/16	3 7/8	2 7/16
5/8	5/8	1 1/8	23/32	2 1/8	2 1/8	4	2 1/2
11/16	11/16	1 3/16	25/32	2 3/16	2 3/16	4 1/8	2 9/16
3/4	3/4	1 1/4	7/8	2 1/4	2 1/4	4 1/4	2 5/8
13/16	13/16	1 5/16	15/16	2 5/16	2 5/16	4 3/8	2 11/16
7/8	7/8	1 1/2	1	2 3/8	2 3/8	4 1/2	2 3/4
15/16	15/16	1 5/8	1 1/16	2 7/16	2 7/16	4 5/8	2 13/16
1	1	1 3/4	1 1/8	2 1/2	2 1/2	4 3/4	2 7/8
1 1/16	1 1/16	1 13/16	1 3/16	2 9/16	2 9/16	4 7/8	2 15/16
1 1/8	1 1/8	1 7/8	1 5/16	2 5/8	2 5/8	5	3
1 3/16	1 3/16	1 15/16	1 3/8	2 11/16	2 11/16	5	3 1/16
1 1/4	1 1/4	2	1 7/16	2 3/4	2 3/4	5 1/8	3 1/8
1 5/16	1 5/16	2 1/8	1 1/2	2 13/16	2 13/16	5 1/8	3 3/16
1 3/8	1 3/8	2 1/4	1 9/16	2 7/8	2 7/8	5 1/4	3 1/4
1 7/16	1 7/16	2 3/8	1 5/8	2 15/16	2 15/16	5 1/4	3 5/16
1 1/2	1 1/2	2 1/2	1 3/4	3	3	5 3/8	3 1/2
1 9/16	1 9/16	2 5/8	1 13/16				

Woodruff Keys



Woodruff keys are suitable for shafts up to 2½ ins. diameter,

Woodruff Keys—*Continued*

but they cannot be used as sliding keys.

Number of Key	Dia. of Key A	Thickness B	Depth of keyway C	D	Ultimate shearing strength lbs.	Number of Key	Dia. of Key A	Thickness B	Depth of keyway C	D	Ultimate shearing strength lbs.
1	1/2	1/16	1/32	3/64	1,566	19	1 1/4	3/16	3/32	5/64	11,718
2	1/2	3/32	3/64	3/64	2,350	20	1 1/4	7/32	7/64	5/64	13,671
3	1/2	1/8	1/16	3/64	3,132	21	1 1/4	1/4	1/8	5/64	15,625
4	5/8	3/32	3/64	1/16	2,937	D	1 1/4	5/16	5/32	5/64	19,530
5	5/8	1/8	1/16	1/16	3,915	E	1 1/4	3/8	3/16	5/64	23,436
6	5/8	5/32	5/64	1/16	4,894	22	1 3/8	1/4	1/8	3/32	17,187
7	3/4	1/8	1/16	1/16	4,700	23	1 3/8	5/16	5/32	3/32	21,484
8	3/4	5/32	5/64	1/16	5,872	F	1 3/8	3/8	3/16	3/32	25,781
9	3/4	3/16	3/32	1/16	7,050	24	1 1/2	1/4	1/8	7/64	18,750
10	7/8	5/32	5/64	1/16	6,850	25	1 1/2	5/16	5/32	7/64	23,437
11	7/8	3/16	3/32	1/16	8,221	G	1 1/2	3/8	3/16	7/64	28,125
12	7/8	7/32	7/64	1/16	9,591	26	2 1/8	3/16	3/32	17/32	15,910
A	7/8	1/4	1/8	1/16	10,961	27	2 1/8	1/4	1/8	17/32	20,888
13	1	3/16	3/32	1/16	9,375	28	2 1/8	5/16	5/32	17/32	25,312
14	1	7/32	7/64	1/16	10,937	29	2 1/8	3/8	3/16	17/32	29;702
15	1	1/4	1/8	1/16	12,500	30	3 1/2	3/8	3/16	13/16	53,850
B	1	5/16	5/32	1/16	15,625	31	3 1/2	7/16	7/32	13/16	61,840
16	1 1/8	3/16	3/32	5/64	10,545	32	3 1/2	1/2	1/4	13/16	69,525
17	1 1/8	7/32	7/64	5/64	12,305	33	3 1/2	9/16	9/32	13/16	76,781
18	1 1/8	1/4	1/8	5/64	14,062	34	3 1/2	5/8	5/16	13/16	83,918
C	1 1/8	5/16	5/32	5/64	17,575						

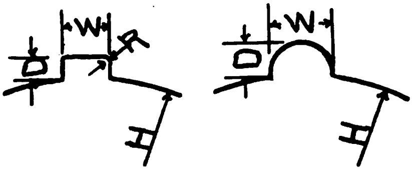
[Whitney Mfg. Co., Hartford, Conn.]

Woodruff Keys to Use with Various Shafts

Dia. of Shaft	Numbers of Keys—see above table	Dia. of Shaft	Numbers of Keys	Dia. of Shaft	Numbers of Keys
5/16–3/8	1	7/8–1 5/16	6, 8, 10	1 3/8–1 7/16	14, 17, 20
7/16–1/2	2, 4	1	9, 11, 13	1 1/2–1 5/8	15, 18, 21, 24
9/16–5/8	3, 5	1 1/16–1 1/8	9, 11, 13, 16	1 11/16–1 3/4	18, 21, 24
11/16–3/4	3, 5, 7	1 3/16	11, 13, 16	1 13/16–2	23, 25
13/16	6, 8	1 1/4–1 5/16	12, 14, 17, 20	2 1/16–2 1/2	25

If the pulley or gear to be keyed on the shaft has an exceptionally long hub, then two keys should be fitted.

Keyways for Milling Cutters



Square Keyway

Dia. hole, H....	3/8–9/16	5/8–7/8	15/16–1 1/8	1 3/16–1 3/8	1 7/16–1 3/4	1 13/16–2	2 1/16–2 1/2	2 9/16–3
Width key, W..	3/32	1/8	5/32	3/16	1/4	5/16	3/8	7/16
Depth, D.......	3/64	1/16	5/64	3/32	1/8	5/32	3/16	3/16
Radius, R......	.020	.030	.035	.040	.050	.060	.060	.060

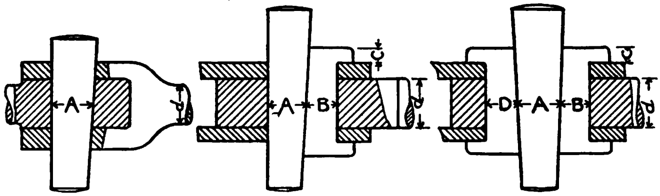
Half-Round Keyway

Dia. hole, H...........	3/8–5/8	11/16–13/16	7/8–1 3/16	1 1/4–1 7/16	1 1/2–2	2 1/16–2 7/16	2 1/2–3
Width, W.............	1/8	3/16	1/4	5/16	3/8	7/16	1/2
Depth, D.............	1/16	3/32	1/8	5/32	3/16	7/32	1/4

[Pratt & Whitney, Hartford, Conn.]

Gibs and Keys

(Cottered Joints)



Taper of key 1/20 to 1/100, if more than 1/25 the key is likely to slip.

d = dia. of rod C = .2d

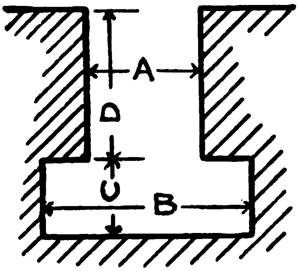
A = 1.2d D = .4d

Thickness of key at center = .3 d

B = .4d

MISCELLANEOUS FASTENINGS

T Slots



Width of Slot A Ins.	Dia. of Neck of Cutter	Width of Slot B	Depth C	Extreme Limit D
5/16	9/32	5/8	5/32	3/8
3/8	11/32	11/16	7/32	7/16
7/16	3/8	13/16	7/32	7/16
1/2	7/16	15/16	9/32	9/16
5/8	17/32	1 3/16	13/32	3/4
3/4	21/32	1 5/16	17/32	1
7/8	25/32	1 5/8	11/16	1 1/16
1	29/32	1 7/8	13/16	1 3/16

[Brown & Sharpe, Prov., R. I.]

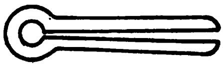
Bolt Heads for T Slots

Width of slot A Ins.	Diameter bolt	Side of sq. bolt head	Thickness of head
5/16	1/4	9/16	1/8
3/8	5/16	5/8	3/16
7/16	3/8	3/4	3/16
1/2	7/16	7/8	1/4
5/8	1/2	1 1/8	3/8
3/4	5/8	1 1/4	1/2
7/8	3/4	1 9/16	5/8
1	7/8	1 13/16	3/4

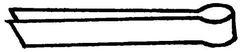
Spring Cotters

Wire Gauge	Diameter	Lengths*	Wire Gauge	Diameter	Lengths*
13	3/32	1/2 to 2	7	3/16	3/4 to 3
12	7/64	1/2 " 2	6	13/64	3/4 " 3
11	1/8	1/2 " 2 1/2	5	7/32	1 " 3
10	9/64	1/2 " 2 1/2	4	1/4	1 " 4
9	5/32	1/2 " 2 1/2	1	5/16	1 " 4
8	11/64	1/2 " 2 1/2			

* Advancing by 1/4".



Spring Cotter



Flat Spring Key

Flat Spring Keys

Width	Length									
3/8	1 1/4	1 1/2	1 3/4	2	2 1/4	2 1/2	2 3/4	3		
1/2	1 1/4	1 1/2	1 3/4	2	2 1/4	2 1/2	2 3/4	3		
5/8			1 3/4	2	2 1/4	2 1/2	2 3/4	3	3 1/4	3 1/2
3/4				2	2 1/4	2 1/2	2 3/4	3	3 1/4	3 1/2

[F. P. Smith & Co., Sharon Hill, Pa.]

SECTION III

POWER TRANSMISSION

SHAFTING — QUILL DRIVES — COUPLINGS — CLUTCHES — COLLARS — BEARINGS — PULLEYS — MULE STANDS — BELTING — BELT DRIVES — ROPE SHEAVES AND PULLEYS — CHAINS FOR TRANSMITTING POWER — SPROCKETS — GEARING: SPUR, MITRE, BEVEL, WORM, HERRINGBONE — THRUST OF SPIRAL AND HELICAL GEARS

SHAFTING

Rolled shafts for power transmission in mills and factories can be obtained up to 8 ins. dia., and in stock lengths 10, 12, 14, 16, 18, 20, 22 and 24 ft. lengths. For general use the sizes in the table are recommended.

Dia.	Weight lbs. per ft.	Dia.	Weight lbs. per ft.	Dia.	Weight lbs. per ft.
1 3/16	3.76	2 7/16	15.86	4 7/16	52.58
1 7/16	5.52	2 15/16	23.04	4 15/16	65.10
1 11/16	7.60	3 3/16	27.13	5 7/16	78.95
1 15/16	10.02	3 7/16	31.56	5 15/16	94.14
2 3/16	12.78	3 15/16	41.40		

Forged steel shafting is preferable to rolled for sizes 6 ins. dia. and above, as it is stronger and more homogeneous. Forged steel shafting as manufactured by Dodge Manufacturing Co. has the following characteristics: tensile strength per sq. in. 60,000 to 70,000 lbs., elastic limit 30,000 to 36,000 lbs., elongation in 2 ins. 25 to 30%, reduction in area 40%.

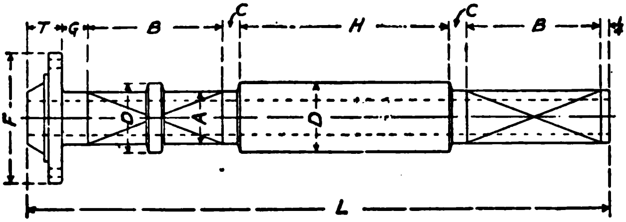
Shafting in machine shops should run at about 160 rev. per min., and in wood working shops 250.

Shafting should be supported so the deflection is not greater than .01 in. per ft. See pages 93 and 106.

QUILL DRIVES

For heavy duty and where it is necessary to use a clutch on the driving shaft, quill drives can be installed to advantage.

A quill is a hollow shaft, usually cast iron, larger in diameter than the line shaft. The quill is supported by independent bearings (indicated by crosses in the figure) the clutch is attached to the face F, and at H is keyed the pulley. The clutch when disengaged is stationary. The line shaft supported by its own bearings revolves but does not come in contact with the quill. The quill relieves the line shaft of the weight of the pulley and belt pull.



DIMENSIONS IN INCHES

Shaft Sizes	A	B	C	D	G	H	F and T	Keyseat in Swell
2 15/16	5 11/16	12	3/4	6 11/16	1 3/4	Not less than width of face of pulley.	Determined by size of clutch used.	1 1/4 x 1/4
3 7/16	3 3/16	14	3/4	7 3/16	1 3/4			1 1/2 x 1/4
3 15/16	6 11/16	14	3/4	7 11/16	2			1 3/4 x 1/4
4 7/16	7 7/16	16	3/4	8 7/16	2			1 3/4 x 1/4
4 15/16	8 3/16	16	3/4	9 3/16	2			2 x 3/8
5 7/16	8 11/16	18	3/4	9 11/16	2 1/4			2 x 3/8
5 15/16	9 3/16	18	3/4	10 3/16	2 1/4			2 1/4 x 3/8
6 7/16	10 3/16	21	3/4	11 3/16	2 1/2			2 1/2 x 3/8
6 15/16	10 11/16	21	3/4	11 11/16	2 1/2			2 3/4 x 3/8
7 7/16	11 11/16	24	3/4	12 11/16	2 3/4			3 x 3/8
7 15/16	12 3/16	24	3/4	13 3/16	2 3/4			3 x 3/8

[T. B. Wood's Sons Co., Chambersburg, Pa.]

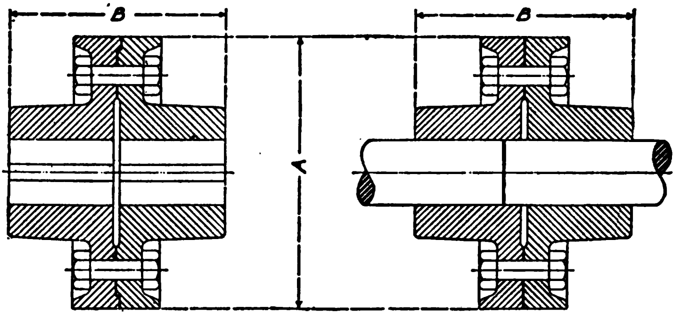
Horse Powers of Shafting under Different Conditions

Dia. of Shaft Ins.	For head shafts, heavy strains, shafts with gears, etc. H. P. = $\frac{D^3R}{125}$								For line shafts, with bearings every 8 ft. H. P. = $\frac{D^3R}{75}$								For simple transmission of power with no bending strains. H. P. = $\frac{D^3R}{50}$							
	Revolutions per minute								Revolutions per minute								Revolutions per minute							
	50	100	150	200	250	300	400	500	50	100	150	200	250	300	400	500	50	100	150	200	250	300	400	500
1 3/16	0.6	1.3	1.8	2.6	3.3	4	5	6	1	2	3	4	6	7	9	11	2	3	5	7	8	10	13	17
1 7/16	1.2	2.3	4	5	6	7	9	12	2	4	6	8	10	12	16	20	3	6	9	12	15	18	24	30
1 11/16	2	4	6	8	10	11	15	19	3	6	10	13	16	19	26	32	5	10	14	19	24	29	38	48
1 15/16	3	6	9	12	15	17	23	29	5	10	15	19	24	29	39	48	7	15	22	29	36	44	58	73
2 3/16	4	8	13	17	21	25	33	42	7	14	21	28	35	42	56	70	10	21	31	42	52	63	84	105
2 7/16	6	12	17	23	29	34	46	58	10	19	29	39	48	58	77	97	14	29	43	58	72	87	116	145
2 11/16	8	15	23	31	39	46	62	78	13	26	39	52	65	78	104	129	19	39	58	78	97	117	155	194
2 15/16	10	20	30	40	50	61	81	100	17	34	51	68	85	101	135	169	25	51	76	101	127	152	203	254
3 7/16	16	32	49	65	81	97	130	162	27	54	81	108	135	163	217	271	41	81	122	163	203	244	325	406
3 15/16	24	49	73	98	122	146	195	244	41	81	122	163	204	244	326	407	61	122	183	244	305	366	488	610
4 7/16	35	70	105	140	175	210	280	...	58	117	175	233	291	350	466	...	87	175	262	350	437	524	699	...
4 15/16	48	96	144	192	240	290	385	...	80	161	241	321	401	481	642	...	120	241	361	482	602	723	963	...
5 7/16	66	133	200	265	332	400	...	...	111	222	333	444	555	666	..	...	166	333	499	666	832	998	...	...
6	86	173	260	345	432	520	...	...	144	288	432	576	720	..	..	...	216	432	648	864	1080	1296	...	...
6 1/2	110	220	330	440	550	...	...	...	183	366	549	732	915	..	..	...	275	549	824	1099	1373	....	...	...
7	137	275	412	550	686	...	...	...	229	457	686	915	1143	..	..	...	343	686	1029	1372	1715	....	...	...
7 1/2	170	337	506	675	...	...	...	...	281	563	844	1125	...	..	..	...	422	844	1266	1688	....	....	...	...
8	205	410	614	820	...	...	...	...	341	683	1024	1365	...	..	..	...	512	1024	1536	2048	....	....	...	...

Dodge Sales & Eng'g Co., Mishawaka, Ind.]
[In formulæ—D = dia. of shaft, and R = rev. per min.

COUPLINGS

Flange Couplings

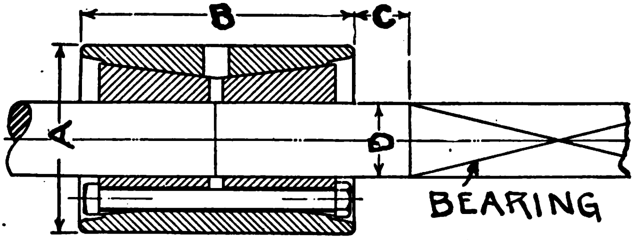


Male and Female Type — Standard Plain Face Type

Shaft Sizes	A	B	Shaft Sizes	A	B
1 3/16	6	4 5/8	3 11/16	12	10
1 7/16	6 3/4	5 1/8	3 15/16	12 1/2	10 5/8
1 11/16	7 1/4	5 3/4	4 7/16	13 1/2	13 5/8
1 15/16	8	6 3/8	4 15/16	16 1/4	14 3/8
2 3/16	8 1/2	6 7/8	5 7/16	17 1/2	15 1/8
2 7/16	9	7 3/8	5 15/16	19	16 1/8
2 11/16	9 3/4	7 7/8	6 7/16	20	16 3/4
2 15/16	10 1/2	8 3/8	6 15/16	21	17 1/2
3 3/16	10 7/8	8 7/8	7 7/16	22 1/2	18 1/2
3 7/16	11 1/4	9 3/8	7 15/16	24	19 1/2

Couplings are forced on shafts by hydraulic press and keyed. Shafts are then centered in a lathe and the couplings faced. Number of bolts = .78 dia. of shaft + 2. Bolt dia. = .13 dia. of shaft + 1/4″. Total thickness of web = .5 dia. of shaft + 3/8″.

Double Cone Compression Couplings

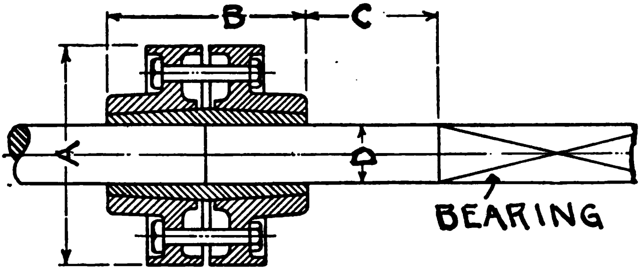


D Shaft Sizes Ins.	A	B	C	D Shaft Sizes Ins.	A	B	C
1 15/16	5 1/2	7 7/8	3	4 15/16	12 1/4	18	7 1/2
2 3/16	6	8 5/8	3 3/8	5 7/16	13 1/4	19 3/4	8 1/4
2 7/16	6 5/8	9 1/2	3 3/4	5 15/16	14	21 1/2	9
2 11/16	7	10 1/4	4 1/8	6 7/16	15 1/4	23 1/4	9 3/4
2 15/16	7 7/8	11 1/2	4 1/2	6 15/16	16 1/4	25	10 1/2
3 3/16	8 1/4	12 1/4	4 7/8	7 7/16	17 1/2	27	11 1/4
3 7/16	9	13	5 1/4	7 15/16	18 1/2	29	12
3 11/16	9 5/8	14 1/4	5 5/8	8 7/16	20 1/2	32	13 1/2
3 15/16	10 1/8	15	6	8 15/16	20 1/2	32	13 1/2
4 7/16	11 1/4	16 1/2	6 3/4				

[T. B. Wood's Sons Co., Chambersburg, Pa.]

The coupling consists of shell, two cones and bolts. Each cone has a keyway cut in it as also in each end of the shafts. By drawing up the bolts an equal pressure is exerted on the cones, which are compressed and drawn into the outside shell. With this type of coupling the shafts may be slightly out of alignment yet transmit power satisfactorily.

Universal Giant Compression Couplings

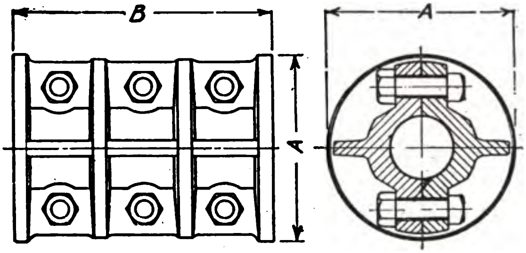


D Shaft Sizes Inches	Dimensions in Inches A	B	C	D Shaft Sizes Inches	Dimensions in Inches A	B	C
15/16	4 5/8	3 3/4	2	2 11/16	9 1/4	9 5/8	4 7/8
1 3/16	5 3/8	4 3/8	2 1/4	2 15/16	10	10 1/2	5 1/4
1 7/16	6 1/4	5 1/4	2 5/8	3 3/16	10 3/4	10 1/2	5 1/4
1 11/16	6 1/2	6 1/8	3 1/8	3 7/16	12	11 3/8	5 3/4
1 15/16	7 3/8	7	3 1/2	3 11/16	12 1/2	12 1/4	6 1/4
2 3/16	7 3/4	7 7/8	4	3 15/16	13	13	6 3/4
2 7/16	9	8 3/4	4 3/8				

[T. B. Wood's Sons Co., Chambersburg, Pa.]

This type of coupling is suitable for repairing a broken shaft quickly. It is designed to use without shaft keys, and consists of a slotted sleeve with a reverse taper on the outside, and compression flanges. By tightening bolts in the flanges, they are drawn together causing the sleeve to grip the shaft. To obtain an even grip the flanges should be equidistant.

Ribbed Compression Couplings



Dia. of Shaft	A	B	Number of Bolts	Dia. of Bolts
1 3/16	4 1/8	5 1/2	4	3/8
1 7/16	4 3/4	6 1/4	4	3/8
1 11/16	5	7	4	3/8
1 15/16	6	8 1/4	4	3/8
2 3/16	6 3/8	8 7/8	4	1/2
2 7/16	7 1/4	9 7/8	6	5/8
2 11/16	7 1/2	10 7/8	6	5/8
2 15/16	8 3/4	11 3/4	6	3/4
3 3/16	9 1/4	12 3/4	6	7/8
3 7/16	10	13 3/4	6	7/8
3 15/16	10 5/8	14 7/8	6	7/8
4 7/16	12	16 1/2	6	7/8
4 15/16	13 5/8	18 1/8	6	7/8

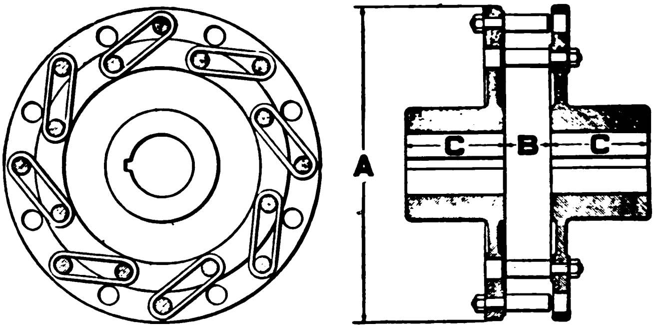
Keys are required. [T. B. Wood's Sons Co., Chambersburg, Pa.]

Ring Compression Couplings

These couplings consist of two half sleeves tapered on the outside and two forged steel rings bored to match at each end. In fitting couplings to shafts the rings are driven towards each other, forcing the sleeves to grip the shafts. Keys are required.

Shaft dia.	1 15/16	2 3/16	2 7/16	2 11/16	2 15/16	3 3/16	3 7/16	3 11/16	3 15/16	4 7/16	4 15/16	5 7/16	5 15/16
Length of coupling...	8	9	10	11	12	13	14	15	16	18	20	22	24

Flexible Couplings

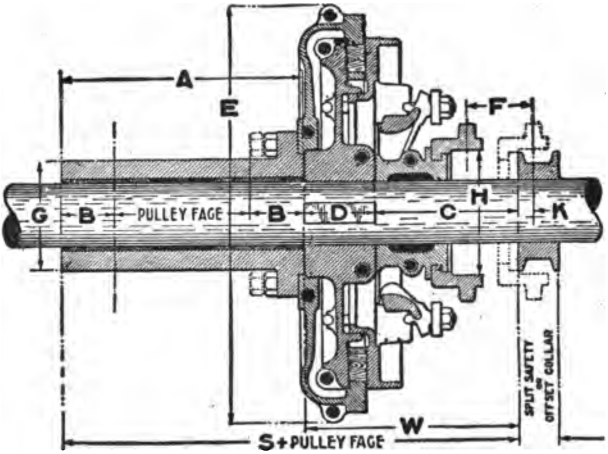


Outside Diameter A Inches	Maximum Shaft Diameter Inches	No. of Links	B Inches	C Inches	H. P. at 100 Rev. Steady Load
5	$\frac{15}{16}$	3	1	$1\frac{3}{4}$	1
7	$1\frac{3}{16}$	3	$1\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{3}{4}$
9	$1\frac{7}{16}$	4	$1\frac{1}{2}$	3	$4\frac{3}{4}$
12	$1\frac{15}{16}$	3	$2\frac{1}{8}$	$3\frac{1}{2}$	$11\frac{1}{2}$
12	$2\frac{3}{16}$	4	$2\frac{1}{8}$	$3\frac{1}{2}$	15
15	$2\frac{7}{16}$	4	$2\frac{1}{8}$	4	21
18	$3\frac{3}{16}$	4	$3\frac{5}{8}$	6	47
18	$3\frac{7}{16}$	6	$3\frac{5}{8}$	6	67
24	$3\frac{15}{16}$	6	$3\frac{5}{8}$	7	98
24	$4\frac{7}{16}$	8	$3\frac{5}{8}$	7	130
30	$4\frac{15}{16}$	6	$5\frac{1}{4}$	9	225
30	$5\frac{7}{16}$	8	$5\frac{1}{4}$	9	300
36	$5\frac{15}{16}$	8	$5\frac{1}{4}$	$11\frac{1}{2}$	380
36	$6\frac{7}{16}$	10	$5\frac{1}{4}$	$11\frac{1}{2}$	480
42	$6\frac{15}{16}$	10	$6\frac{1}{4}$	13	680
42	$7\frac{7}{16}$	12	$6\frac{1}{4}$	13	820
48	$7\frac{15}{16}$	12	$6\frac{1}{4}$	14	960
54	$8\frac{7}{16}$	12	$7\frac{1}{4}$	15	1220
54	$8\frac{15}{16}$	14	$7\frac{1}{4}$	15	1420
60	$9\frac{7}{16}$	16	$7\frac{1}{4}$	$16\frac{1}{2}$	1710
72	$10\frac{15}{16}$	12	$7\frac{1}{4}$	18	2360
72	$11\frac{7}{16}$	14	$7\frac{1}{4}$	18	2770
72	$11\frac{15}{16}$	16	$7\frac{1}{4}$	18	3160

[Cresson-Morris Co., Phila., Pa.]

CLUTCHES

Split Friction Clutch



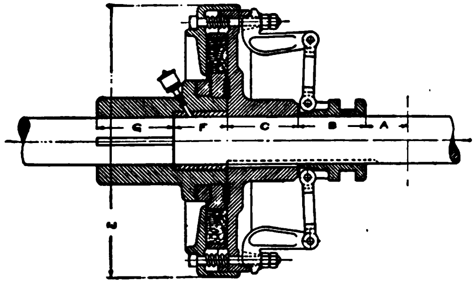
Clutch Sizes Ins.	Max. dia. of Shaft	B	C	D	E	F	G	H	K	S	W
10	2 1/2	2 1/2	6 7/8	3 3/4	14	2 1/4	To suit bore of pulley	4 1/2	1	15 5/8	10 5/8
12	3	2 1/2	7 13/16	3 3/4	17	2 5/8		4 1/2	3/4	16 9/16	11 9/16
14	3 1/2	2 1/2	8 1/2	4 1/4	19	3		5 7/8	3/4	17 3/4	12 3/4
16	4 1/2	3	8 3/4	4 1/4	21	3		6	1 3/8	19	13
18	5	3	8 7/8	4 1/8	23	3 5/8		7	7/8	19	13
20	6	3	8 13/16	4 3/4	25 1/2	3 5/8		7 3/4	1	19 9/16	13 9/16
22	6	3	9 1/8	4 5/8	27	4		8 1/4	1 1/4	19 3/4	13 3/4
24	6 1/2	3	9 5/8	4 3/4	29 1/4	4 3/8		8 5/8	1 3/8	20 3/8	14 3/8
28	7	3 1/2	11	5 1/2	34 1/4	5		9 3/4	1	23 1/2	16 1/2
30	7 1/2	3 1/2	11 1/2	7 1/4	34	6 1/2		9 3/4	1 1/4	25 3/4	18 3/4
36	8		11	7 7/8	40 1/4	7		11 1/8	1 7/8		18 7/8
42	10		12 7/8	9 7/8	48	8 7/8		11 3/4	2 1/16		22 3/4
48	10		13 5/8	11	54	9 3/8		14 1/2	1 7/8		24 5/8
54	12	Use quills	16	12 3/8	60 1/2	11	Use quills	14 3/4	1 5/8	Use quills	28 3/8
60	12		16 1/2	13 5/8	67 3/4	11		14 1/2	1 3/4		30 1/8
72	15		20 3/4	16	83	13 1/4		19 1/2	2		36 3/4

Note—For clutches over 30 inches, quills are recommended in place of sleeves: A = pulley face + 2B. Cut off couplings for the sizes given. A = 6¼, 6¼, 6¼, 8, 8, 8, 8, 8, 11, 11, 12⅝, 14¾, 16½, 18⅛, 19⅝, 22½.

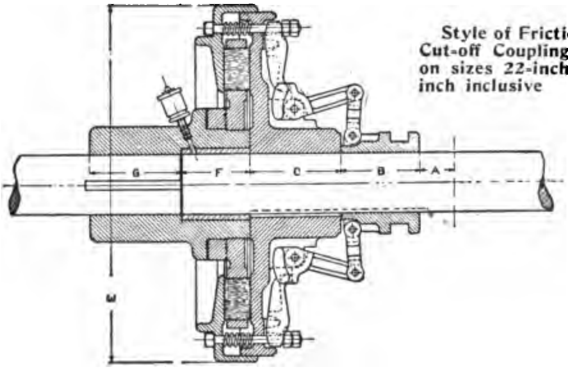
[Dodge Sales & Eng'g Co., Mishawaka, Ind.]

Friction Clutch

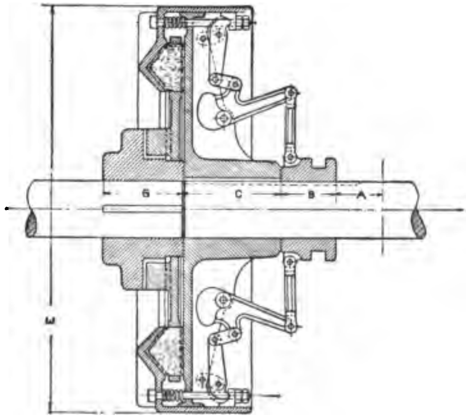
Style of Friction Clutch Cut-off Coupling as used on sizes up to 20-inch inclusive



Style of Friction Clutch Cut-off Coupling as used on sizes 22-inch and 32-inch inclusive



Style of Friction Clutch Cut-off Coupling as used on 37-inch and 43-inch

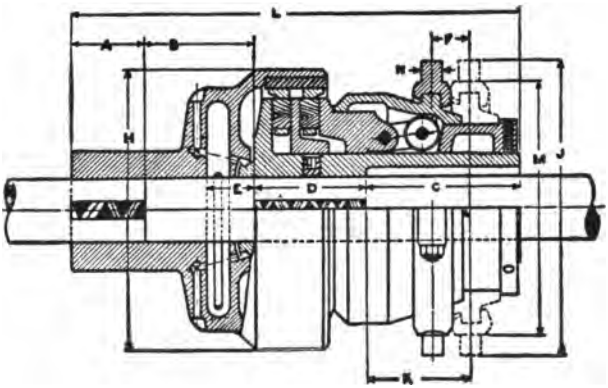


Friction Clutch—*Continued*

Size of Clutch Inches	Diameter of Shaft	Highest Speed Cut-off Should Run	H. P. at 100 R. P. M. under normal conditions	Dimensions of Whole Clutches Only						Weight Pounds
				A	B	C	E	F	G	
5	15/16	400	1 3/4	1	2 1/2	2 3/4	7 3/4	2	3 1/2	33
6	1 3/16	400	2 1/2	1 1/2	2 1/2	2 3/4	9	2 1/2	4	42
8	1 7/16	400	5	1 3/8	2 1/2	3	11	3 1/4	4 1/4	68
10	1 11/16	350	7	1 1/2	3	3 3/4	13	3 1/2	5	115
12	1 15/16	300	12	2	4	4 1/4	15 1/2	4	6	202
14	2 3/16	275	18	2 1/4	5 1/8	5 1/8	18	4 1/2	6	295
16	2 7/16	250	25	2 1/2	5	5 1/2	20 1/4	4 1/2	6 1/2	367
18	2 11/16	225	34	2 3/4	5	5 1/2	22 1/4	5	6 1/2	479
20	2 15/16	200	45	3 1/2	6 1/4	6 1/2	25 1/2	5	7	715
22	3 3/16	200	55	3 1/2	6	7 1/4	28	5 1/4	7 1/2	862
24	3 7/16	200	65	3 1/4	6 1/2	7 1/4	29 3/4	5 1/2	7 3/4	1010
28	3 15/16	200	85	4 1/2	6 3/4	8 1/4	34	6	8 1/8	1269
32	4 7/16	200	112	5	7 1/2	9 1/4	39	6 3/4	9	1765

[Moore & White Co., Phila., Pa.]

Safety Type Multiple Disc Solid Clutch Coupling



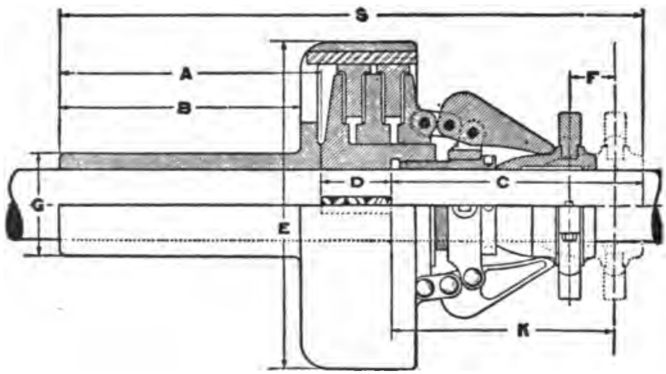
Clutch Size, Inches	A	B	C	D	E	F	H	J	K	L	M	N
6	2	2 3/4	4 1/8	3	1 1/4	1	7 5/8	8	2 3/4	11 7/8	6 7/8	9/16
8	2 1/4	3 1/4	4 7/8	4	1 3/8	1	10 1/8	10 3/8	3 3/8	14 3/8	9 1/4	5/8
10	3	3 3/4	5 3/8	4 1/2	1 5/8	1 1/4	12 5/8	11 5/8	3 11/16	16 5/8	10 3/8	11/16
12	3 1/2	4 1/2	7 3/16	5	1 11/16	1 3/4	15 1/8	13 3/8	5 3/16	20 3/8	11 7/8	13/16
14	4	5	7 3/8	5 3/4	1 7/8	1 3/4	17 1/2	16 1/2	6 1/16	22 1/8	14 3/4	15/16

Horse Power Capacities, Largest Bores and Safe Speeds
Multiple Disc Solid Clutch Coupling

Clutch Size, Inches	H. P. at 100 R. P. M.	Largest Possible Bore, Inches	Size of Shaft Equal in Capacity to Coupling, Inches	Speed Allowable for Coupling as Ordinarily Made
6	4	2	1 7/16	560
8	8	2 3/4	1 15/16	520
10	15	3 1/4	2 3/16	480
12	25	3 3/4	2 7/16	440
14	40	4 1/2	2 15/16	400

[Dodge Sales & Eng'g Co., Mishawaka, Ind.]

Solid Friction Clutch



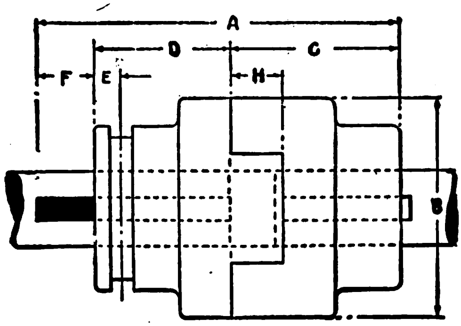
Size of Clutch Ins.	Largest Shaft		A	B	C	D	E	F	K	S
	Reg.	Specl.								
4	1 1/4	.....	4 1/2	4	4 3/4	1 1/2	5 3/8	3/4	4 3/8	10 3/4
5	1 1/2	.....	5	4 1/2	4 3/4	1 3/4	6 1/2	3/4	4 3/8	11 1/2
6	1 3/4	.....	6	5 1/2	6 3/8	1 7/8	7 11/16	1 1/4	5 7/8	14 1/4
7	2	.....	7	6 1/4	6 7/8	2 1/8	8 7/8	1 1/4	6 3/8	16
8	2 1/4	.....	8	7 1/4	7 1/2	2 1/4	10 1/8	1 1/2	7	17 3/4
9	2 1/2	.....	10	9 1/4	7 5/8	2 3/8	11 3/8	1 1/2	7	20
10	3	.....	11	10 1/4	7 1/2	2 1/2	12 5/8	1	6 7/8	21
12	3	4	12	11	8 1/2	2 3/4	15 1/8	1 1/4	7 3/4	23 1/4
14	3 1/2	5	13	12	9	3	17 5/8	1 1/4	8 1/8	25
16	4 1/2	6	14	13	9 7/8	4 1/8	19 1/2	1 1/2	9	28

[Dodge Sales & Eng'g Co., Mishawaka, Ind.]

This clutch is adapted particularly for use on countershafts and other places where a solid clutch is required.

Size of Clutch, ins.	Max. Rev. per Min.	Horse Power	Size of Clutch, ins.	Max. Rev. per Min.	Horse Power
4	500	5½	9	500	23
5	500	9	10	500	40
6	500	12	12	450	59
7	500	16	14	400	102
8	500	19	16	400	170

Jaw Clutch

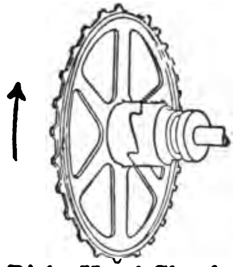


Shaft Size, Ins.	A	B	C	D	E	F	H	Shaft Size, Ins.	A	B	C	D	E	F	H
15/16	6¾	3¼	3⅛	2½	½	1⅛	⅞	3 7/16	14⅛	9⅜	6½	5⅜	15/16	2¼	1⅞
1 3/16	7⅝	4	3½	2⅞	⅝	1¼	1	3 15/16	15⅜	10½	7	6	1 1/16	2⅜	2
1 7/16	8⅜	4½	3⅞	3⅛	⅝	1⅜	1⅛	4 7/16	16⅝	11¾	7⅞	6¼	1 3/16	2½	2⅛
1 11/16	9⅛	5¼	4⅛	3½	11/16	1½	1⅛	4 15/16	18¾	13	8½	7¼	1 3/16	3	2½
1 15/16	9⅞	5⅞	4½	3¾	11/16	1⅝	1¼	5 7/16	20¼	14¾	9¼	7¾	1 3/16	3¼	2¾
2 3/16	10½	6½	4⅞	3⅞	¾	1¾	1⅜	6	22	16⅛	10	8½	1⅜	3½	3
2 7/16	11⅝	7	5¼	4½	¾	1⅞	1½	6 ½	23¾	17¼	10¾	9¼	1⅝	3¾	3¼
2 11/16	12⅛	7¾	5½	4⅝	⅞	2	1⅝	7	25½	18¾	11¾	9¾	1⅝	4	3½
2 15/16	12⅞	8⅛	5⅞	4⅞	⅞	2⅛	1¾								

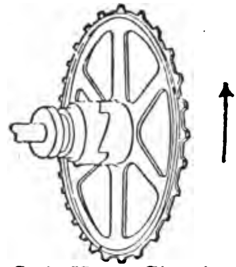
[Dodge Sales & Eng'g Co., Mishawaka, Ind.]

Spiral Jaw Clutch Arrangements

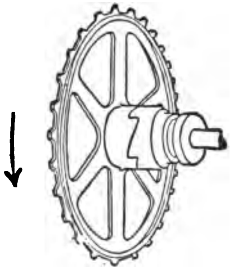
Clutch Drives Wheel



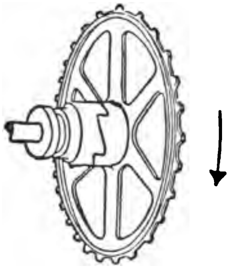
Right-Hand Clutch



Left-Hand Clutch

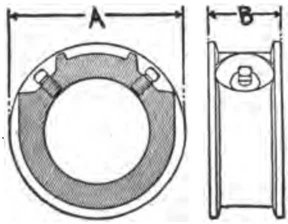


Left-Hand Clutch

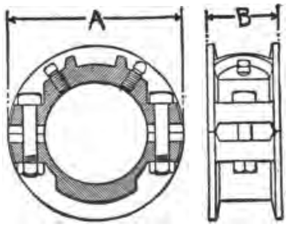


Right-Hand Clutch

SOLID AND SPLIT SAFETY COLLARS



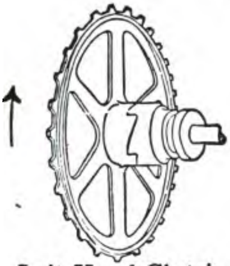
SOLID



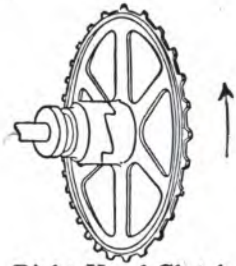
SPLIT

(*See opposite page for table*)

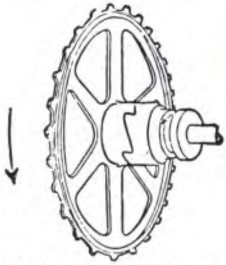
Spiral Jaw Clutch Arrangements
Wheel Drives Clutch



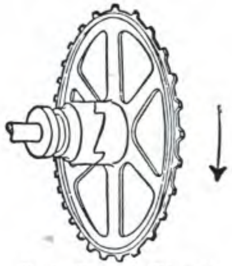
Left-Hand Clutch



Right-Hand Clutch



Right-Hand Clutch



Left-Hand Clutch

SOLID AND SPLIT SAFETY COLLARS—for figure see page 104.

Shaft Size Inches	Solid Collars		Split Collars		Shaft Size Inches	Solid Collars		Split Collars	
	A	B	A	B		A	B	A	B
1 3/16	2 7/16	1 3/8	3 1/8	1 3/8	6 3/4	10 7/8	3 1/2	11	3 1/2
1 7/16	3	1 5/8	3 3/8	1 5/8	7	10 7/8	3 1/2	11	3 1/2
1 11/16	3 3/16	1 5/8	3 5/8	1 5/8	7 1/4	11 3/8	3 1/2	11 5/8	3 1/2
1 15/16	3 7/16	1 5/8	3 7/8	1 5/8	7 1/2	11 3/8	3 1/2	11 5/8	3 1/2
2 3/16	4 1/16	1 7/8	4 11/16	1 7/8	7 3/4	11 7/8	3 1/2	12	3 1/2
2 7/16	4 5/16	1 7/8	4 15/16	1 7/8	8	11 7/8	3 1/2	12	3 1/2
2 11/16	4 9/16	1 7/8	5 3/16	1 7/8	8 1/4	13	3 3/4	13	3 3/4
2 15/16	4 15/16	1 7/8	5 7/16	1 7/8	8 1/2	13	3 3/4	13	3 3/4
3 3/16	5 3/16	2	5 11/16	2	8 3/4	13 1/2	3 3/4	13 1/2	3 3/4
3 7/16	5 7/16	2	5 15/16	2	9	13 1/2	3 3/4	13 1/2	3 3/4
3 11/16	5 15/16	2 1/4	6 5/8	2 1/4	9 1/4	14	3 3/4	14	3 3/4
3 15/16	6 3/16	2 1/4	7	2 1/4	9 1/2	14	3 3/4	14	3 3/4

(Continued on page 106.)

SOLID AND SPLIT SAFETY COLLARS—*Continued*

Shaft Size Inches	Solid Collars A	Solid Collars B	Split Collars A	Split Collars B	Shaft Size Inches	Solid Collars A	Solid Collars B	Split Collars A	Split Collars B
4¼	7⅜	3¼	7¾	3¼	9¾	14½	3¾	14½	3¾
4½	7⅝	3¼	8	3¼	10	14½	3¾	14½	3¾
4¾	7⅞	3¼	8¼	3¼	10¼	15⅝	4	15⅝	4
5	8⅛	3¼	8½	3¼	10½	15⅝	4	15⅝	4
5¼	8⅝	3¼	9	3¼	10¾	16⅛	4	16⅛	4
5½	8⅝	3¼	9	3¼	11	16⅛	4	16⅛	4
5¾	9⅛	3¼	9½	3¼	11¼	16⅝	4	16⅜	4
6	9⅛	3¼	9½	3¼	11½	16⅝	4	16⅝	4
6¼	10⅜	3½	10½	3½	11¾	17⅛	4	17	4
6½	10⅜	3½	10½	3½	12	17⅛	4	17	4

Collars for shafts 3 ins. dia. and under have but one set screw.

[Dodge Sales & Eng'g Co., Mishawaka, Ind.]

BEARINGS

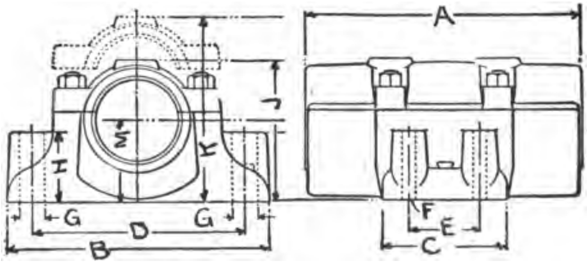
Bearings (pillow block and hanger) in ordinary shop practice are spaced about 8 ft. apart (see page 93). The spacing should be such that the shaft deflection is not greater than .01 ins. per ft.

Length of heavy fixed bearings 2½ to 3½ times the shaft diameter; of light self adjusting 3 to 4½. The allowable bearing pressure in lbs. per sq. in. of projected area babbitt or bronze lined is 100 to 155 lbs.

In locating bearings and in selecting the size of shaft it must be remembered that additional pulleys are often installed after the shafting is in place, and it is necessary to allow for them.

For oiling devices see page 107.

RIGID PILLOW BLOCKS



Shaft Sizes, Inches	A	B	C	D	E	Bolts F	G	H	J	K	M
1 3/16 to 1 1/4	5	7	2 3/8	5 3/8	.....	1/2	1	1 1/2	3 1/8	4 1/4	1 3/4
1 7/16 to 1 1/2	6	6 1/2	2 5/8	5 7/8	.....	1/2	1	1 5/8	3 5/8	5	2
1 11/16 to 1 3/4	6 3/4	8	2 7/8	6 3/8	.....	1/2	1	1 5/8	3 7/8	5	2 1/8
1 15/16 to 2	7 1/2	8 5/8	3	6 3/4	.....	5/8	1 1/4	1 5/8	4 1/8	5 3/8	2 1/4
2 3/16 to 2 1/4	8 1/4	9 1/2	3 3/4	7 5/8	.....	5/8	1 1/4	1 7/8	4 5/8	6	2 1/2
2 7/16 to 2 1/2	9	10 1/4	4	8	.....	3/4	1 1/2	2 1/8	5 1/4	6 3/4	2 3/4
2 11/16 to 2 3/4	9 7/8	11	4 1/8	8 3/4	.....	3/4	1 1/2	2 3/8	5 1/2	7 1/8	3
2 15/16 to 3	10 5/8	11 3/4	4 1/2	9 1/8	.....	7/8	1 3/4	2 1/2	5 3/4	7 5/8	3
3 3/16 to 3 1/4	11 1/8	12 1/2	4 7/8	9 7/8	.....	7/8	1 3/4	2 3/4	6 3/8	8 1/4	3 1/4
3 7/16 to 3 1/2	12	13 1/4	5 1/8	10 1/2	.....	7/8	1 3/4	3	6 5/8	8 5/8	3 1/2
3 11/16 to 3 3/4	12 3/4	14	5 1/2	11 1/8	.....	7/8	1 3/4	3 1/8	7 1/8	9 1/8	3 3/4
3 15/16 to 4	13 1/2	14 1/2	6	11 1/2	.....	7/8	1 3/4	3 1/4	7 5/8	9 5/8	4
4 3/16 to 4 1/4	14 1/4	15	6 1/2	11 7/8	.....	7/8	1 3/4	3 3/8	7 7/8	10	4 1/4
4 7/16 to 4 1/2	15	15 1/2	7	12 1/4	4 1/2	1	2	3 1/2	8 1/4	10 3/4	4 1/2
4 15/16 to 5	16 1/2	17	7 3/4	13 5/8	4 3/4	1	2	3 3/4	9 1/8	12	5
5 7/16 to 5 1/2	18 1/4	18 1/2	8 1/2	15	5	1	2 1/8	4	9 3/4	12 3/4	5 1/2
5 15/16 to 6	19 3/4	20	9 3/8	16 1/4	5 3/8	1 1/8	2 1/8	5	10 3/4	14	6
6 7/16 to 6 1/2	20 1/4	20 3/4	9 7/8	16 7/8	5 5/8	1 1/8	2 1/8	5 5/8	11 3/4	15	6 1/2
6 15/16 to 7	23	22	10 1/2	18	6	1 1/8	2 1/4	6	12 1/2	15 3/4	7
7 7/16 to 7 1/2	24 1/2	23 1/2	11 1/4	19 1/4	6 1/2	1 1/8	2 1/4	6 1/4	13 1/2	17	7 1/2
7 15/16 to 8	26	24 3/4	12	20 1/4	7	1 1/4	2 1/2	6 1/2	14 1/4	18	8
8 7/16 to 8 1/2	27 1/2	25 1/4	12 3/4	20 1/2	7 1/2	1 1/4	2 1/2	6 5/8	15 1/4	19	8 1/2
8 15/16 to 9	29	25 3/4	13 1/2	21	8	1 1/4	2 3/4	6 3/4	15 3/4	19 3/4	9
9 7/16 to 9 1/2	30 1/2	26 7/8	14 1/4	22	8 3/8	1 3/8	2 3/4	7 1/8	16 5/8	21	9 1/2
9 15/16 to 10	32	28	15	23 1/2	9	1 3/8	2 3/4	7 1/8	17 3/8	21 1/4	10
10 7/16 to 10 1/2	33 1/2	29 1/2	16	24 1/2	10	1 1/2	3	7 1/2	18 1/4	22 3/4	10 1/2

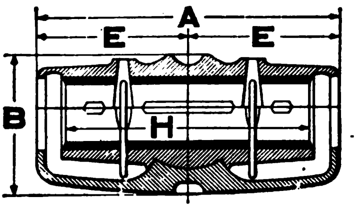
Oil holes at each end of cap are tapped to permit use of grease cups.

[Dodge Sales & Eng'g Co., Mishawaka, Ind.]

LUBRICATING DEVICES FOR BEARINGS

Oil and grease cups. Oil cups are usually cast into the bearing cap and filled with waste saturated with oil. Instead of oil cups, grease cups may be tapped into the cap at each end.

Capillary oilers as made by the Dodge Manufacturing Co. consist of a wood block fastened in the bottom of the bearing sleeve, having alternate saw cuts through which the oil rises by capillary attraction from the reservoir below the sleeve.



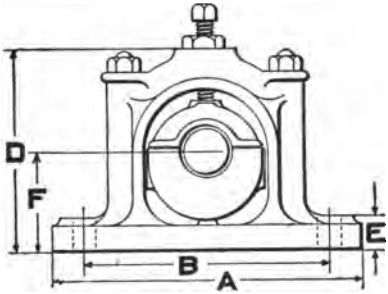
Oiling rings (see figure). The rings as the shaft revolves, bring oil from the reservoir to the shaft.

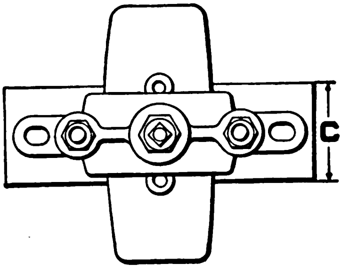
Ring Oiling Bearings—*Continued*

Dia. of Shaft	A	B	E	H	Dia. of Shaft	A	B	E	H
2 7/16	12	5 3/8	6	10	5 7/16	24 1/2	11 1/4	12 1/4	22
2 11/16	13	5 7/8	6 1/2	11	5 15/16	26 3/4	11 3/4	13 3/8	24
2 15/16	14	6 3/8	7	12	6 7/16	29 1/4	12 3/8	14 5/8	26
3 3/16	15	6 7/8	7 1/2	13	6 15/16	30	13 3/4	15	27
3 7/16	16	7 1/2	8	14	7 7/16	31 1/4	14 1/2	15 5/8	28
3 15/16	18	8 3/8	9	16	7 15/16	31 1/2	15 1/4	15 3/4	28
4 7/16	20 3/4	9 3/4	10 3/8	18	8 7/16	31 3/4	16 1/8	15 7/8	28
4 15/16	22 1/2	11 3/8	11 1/4	20					

[Cresson-Morris Co., Phila., Pa.]

Adjustable Pillow Blocks

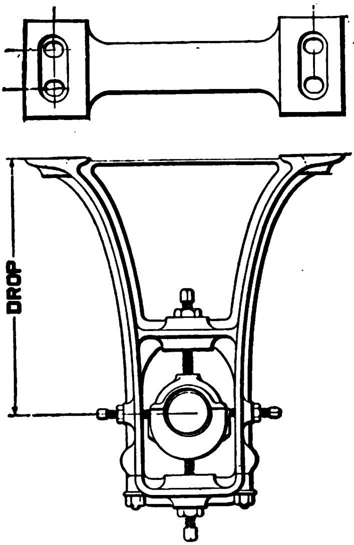




Dia. of Shaft	A	B	C	D	E	F	Bolts	
							No.	Size
In.	In.	In.	In.	In.	In.	In.		In.
$1\frac{3}{16}$	$7\frac{1}{2}$	6	$2\frac{1}{2}$	5	$\frac{3}{4}$	$2\frac{1}{2}$	2	$\frac{1}{2}$
$1\frac{7}{16}$	$8\frac{1}{2}$	7	3	6	1	$3\frac{1}{8}$	2	$\frac{1}{2}$
$1\frac{11}{16}$	$10\frac{1}{2}$	8	$3\frac{1}{2}$	$6\frac{1}{2}$	1	$3\frac{3}{8}$	2	$\frac{5}{8}$
$1\frac{15}{16}$	11	9	4	$7\frac{1}{2}$	1	$3\frac{3}{4}$	2	$\frac{5}{8}$
$2\frac{3}{16}$	$12\frac{1}{2}$	10	$4\frac{1}{2}$	$8\frac{1}{2}$	$1\frac{1}{4}$	$4\frac{1}{8}$	2	$\frac{3}{4}$
$2\frac{7}{16}$	$13\frac{1}{2}$	$10\frac{1}{2}$	5	9	$1\frac{1}{4}$	$4\frac{3}{8}$	2	$\frac{3}{4}$
$2\frac{11}{16}$	14	$11\frac{1}{2}$	$5\frac{1}{2}$	$9\frac{1}{2}$	$1\frac{1}{4}$	$4\frac{5}{8}$	2	$\frac{7}{8}$
$2\frac{15}{16}$	16	$12\frac{1}{2}$	$5\frac{1}{2}$	10	$1\frac{1}{4}$	$5\frac{1}{4}$	2	1
$3\frac{3}{16}$	16	13	$6\frac{1}{2}$	11	$1\frac{1}{4}$	$5\frac{1}{2}$	2	1
$3\frac{7}{16}$	17	$13\frac{1}{2}$	7	$11\frac{1}{2}$	$1\frac{1}{2}$	$5\frac{3}{4}$	2	1
$3\frac{15}{16}$	20	$15\frac{1}{2}$	$7\frac{1}{2}$	$13\frac{1}{2}$	2	$6\frac{5}{8}$	2	$1\frac{1}{8}$
$4\frac{7}{16}$	$22\frac{1}{2}$	$17\frac{1}{2}$	8	15	$2\frac{1}{2}$	7	2	$1\frac{1}{8}$
$4\frac{15}{16}$	$23\frac{1}{2}$	$18\frac{1}{2}$	$8\frac{1}{2}$	16	$2\frac{1}{2}$	$7\frac{5}{8}$	2	$1\frac{1}{4}$
$5\frac{7}{16}$	25	20	$9\frac{1}{2}$	17	$2\frac{1}{2}$	$8\frac{1}{4}$	2	$1\frac{3}{8}$
$5\frac{15}{16}$	$27\frac{1}{2}$	$22\frac{1}{2}$	10	18	$2\frac{1}{2}$	$8\frac{3}{4}$	2	$1\frac{3}{8}$

[Cresson-Morris Co., Phila., Pa.]

HANGERS—8 TO 46 IN. DROP



PULLEYS

Ordering Pulleys.—The following outline can be used to advantage in ordering pulleys.

1. *Service.*—State whether for single or double belt. If neither is specified, single belt pulleys will be furnished.
   If greater horse power than a double belt is required, the horse power, rev. per min. and service should be given.

2. *Description.*—State whether solid, split, clamp hub, flange or special.
   If no description is given, plain solid pulleys will be furnished.
   In sending sketches, follow the instructions on page 111.

3. *Diameter.*—Specify diameter in inches. This should be the first dimension.
   If exact diameter is required, mention this fact and state whether measurement shall be made at crown or edge of rim. An extra charge is made for exact diameter.

4. *Face.*—Specify face in inches. This should be the second dimension given, and should be specified as the width of belt to be used, unless an exact width of face is desired, in which case this should be noted on order by having the word "exact" follow dimension of face.

5. *Bore.*—Specify exact diameter of shaft in inches. This should be the third dimension.
   If shaft is of an odd or special diameter make a gauge to accompany order.
   Never send orders as pulley to be bored $1\frac{15}{16}''$ scant, $2\frac{7}{8}''$ full or about $\frac{1}{64}''$ under $3''$.

6. *Crown or Straight Face.*—After specifying dimensions of pulley, state whether crown or straight face. If neither is specified, crown face pulleys will be furnished.
   Pulleys for belts which do not shift should have crown face.
   Pulleys for shifting belts should have straight face.

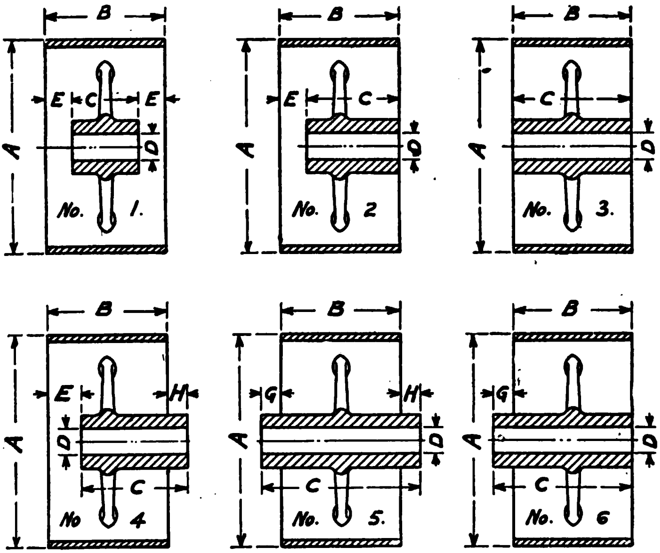
7. *Keyseat or Set Screw.*—State whether keyseated or set screwed or both.
   If neither is specified, set screws only will be furnished.

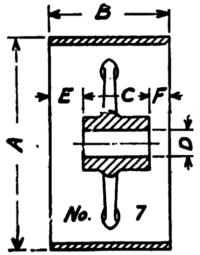
If keyseated, state whether straight or taper.

Pulleys keyseated and not set screwed should have taper keyseat.

Taper keyseats will be cut with ⅛" taper per foot, unless otherwise specified. Split hub pulleys are recommended to have straight keyseat with set screws on top.

[Data from T. B. Wood's Sons Co., Chambersburg, Pa.]





In making sketches, especial care should be taken to indicate those dimensions required to be exact. The bore will always be considered an exact dimension, but the diameter, width of face and length of hub are dimensions which are not always required to be of an exact size.

Cast-iron pulleys are known in the trade by the terms—single belt, double belt and triple belt which terms refer tc leather belting.

Single belt pulleys can be held on the shaft by set screws, while double belt require keys with two set screws over the keyway.

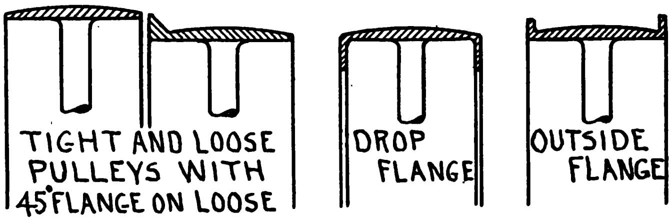
Single and double belt pulleys up to 40 ins. dia. are balanced to run at 300 ft. per min., and over 40 ins. at 3,500.

NUMBER OF ARMS

Dia. of Pulley	Width of Face	Number of Arms	Number of Sets of Arms
up to 14 ins.	up to 19 ins.	4	1
15 " 39 "	" " " "	6	1
	20 " 49 "	6	2
40 " 120 "	up " 19 "	8	1
	20 " 49 "	8	2
	49 and over	8	3

Diameter every half inch from 6 to 24 ins., every inch 25 to 50, and every 2 ins. 52 to 120. Split pulleys can be obtained in nearly all the sizes as solid.

For intermittent driving of a machine, tight and loose pulleys are employed—both having the same diameter with the faces crowned, or one pulley has a 45 deg. flange, with the face crowned, the flange



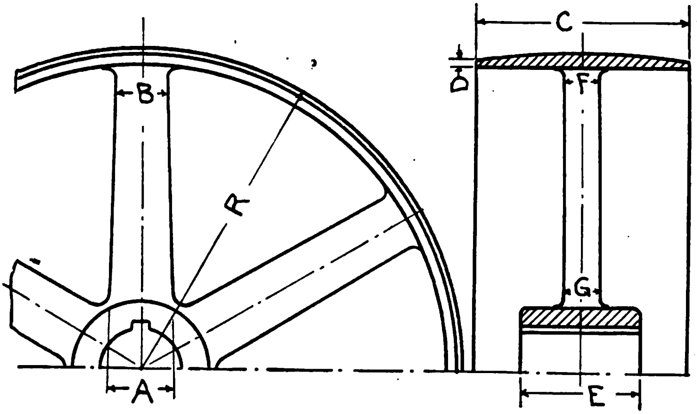
having the same outside diameter as the tight pulley at the edge of the rim, the belt surface being one inch smaller in diameter than that of the tight, thus the belt is relieved of strain when running idle. The hub of the tight pulley is flush with the edge of the rim

on each side, with one end of the hub faced off. The hub of the loose pulley extends ⅛ in. beyond the edge of the rim on each side, with both ends of hub faced off.

Internal or drop flanges greatly strengthen the rim. Pulleys with such flanges are installed when heavy, tight belts are used.

Pulleys can also be obtained with external flanges at center or side.

Proportions



Width of face C = 1.13 × width of belt. D = $^1/_5$ A

R = radius of pulley E = 1⅛ dia. of shaft

$A = \frac{1}{4}'' + \frac{C}{4} + .014R$ F = ½B

B = ¾A G = ½A

Thickness of metal around shaft = .3 dia. of shaft.

Pulleys for shifting belts should have a straight face and for non-shifting a crown. The crown up to 12 ins. in width varies with different manufacturers from ⅛ to ¼ in., and above 12 ins. from ⅛ to ¼ in. per foot. When a belt is shifted from one side of the center line to the other, the face should be straight.

CROWNED CAST IRON PULLEYS

(Gisholt Machine Co.,

Width of Leather Belting	1/2	5/8	3/4	7/8	1	1 1/4	1 1/2	1 3/4	2	2 1/4
Width of Pulley Face	3/4	7/8	1	1 1/8	1 1/4	1 1/2	1 3/4	2	2 1/4	2 1/2
Radius of Crown	5		6 3/4			10 1/2			15	
(Based on Unwin's Formula of 1-24 Width, Appr.)										
Crowning (Rise at Center of Rim.)	.014	.019	.019	.024	.029	.027	.037	.048	.042	.052

PROPORTIONS

Diam.		6			8				10					12				
Face		2	3	4	2	3	4	5	2	3	4	5	6	2	3	4	5	6
RIM	A	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	5/32	5/32	5/32	5/32	5/32	5/32
	B	7/32	1/4	9/32	7/32	1/4	9/32	5/16	7/32	1/4	9/32	5/16	3/8	1/4	9/32	5/16	11/32	3/8
ARM	C	3/4	3/4	7/8	3/4	3/4	7/8	1	7/8	7/8	1	1 1/8	1 1/4	7/8	7/8	1	1 1/8	1 1/4
	D	3/8	3/8	7/16	3/8	3/8	7/16	1/2	3/8	3/8	7/16	1/2	9/16	3/8	3/8	7/16	1/2	9/16
HUB	E	1/2	1/2	9/16	9/16	9/16	5/8	5/8	5/8	5/8	5/8	11/16	11/16	5/8	5/8	5/8	11/16	11/16
	F	1 1/2	2 1/4	2 3/4	1 3/4	2 1/4	2 3/4	3 1/2	1 3/4	2 1/4	2 3/4	3 1/2	4 1/2	1 3/4	2 1/4	2 3/4	3 1/2	4 1/2

Diam.		22							24									
Face		2	3	4	5	6	7	8	3	4	5	6	7	8	9	3	4	5
RIM	A	3/16	3/16	3/16	7/32	7/32	7/32	7/32	7/32	7/32	7/32	7/32	7/32	7/32	7/32	7/32	7/32	7/32
	B	9/32	5/16	11/32	13/32	7/16	15/32	1/2	11/32	3/8	13/32	7/16	15/32	1/2	17/32	11/32	3/8	13/32
ARM	C	1	1	1 1/8	1 1/4	1 1/2	1 1/2	1 3/4	1 1/8	1 1/8	1 1/4	1 1/2	1 3/4	1 7/8	1 7/8	1 1/8	1 1/8	1 1/4
	D	7/16	7/16	1/2	9/16	11/16	11/16	3/4	1/2	1/2	9/16	11/16	3/4	13/16	13/16	1/2	1/2	9/16
HUB	E	11/16	3/4	3/4	3/4	13/16	7/8	7/8	3/4	13/16	13/16	7/8	7/8	15/16	15/16	13/16	13/16	7/8
	F	1 3/4	2 1/2	3 1/2	4 1/4	5 1/4	6	7	2 3/4	3 1/2	4 1/2	5 1/4	6	7	8	2 3/4	3 1/2	4 1/2

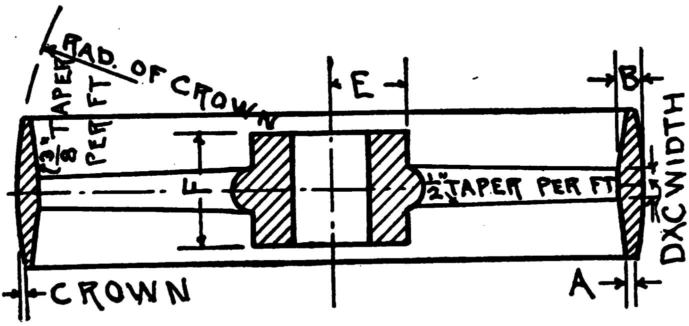
FOR LEATHER BELTING (see Figure on page 116)
Madison, Wis.

2½	2¾	3	3¼	3½	3¾	4	4½	5	5½	6	6½	7	8	9	10	11
2¾	3	3⅜	3⅝	3⅞	4⅛	4⅜	5	5½	6	6½	7	7¾	8¾	10	11	12
	20			25			33			42			56½		70	
.063	.056	.071	.082	.075	.085	.097	.095	.115	.133	.126	.146	.179	.170	.222	.217	.258

OF PULLEYS

14					16						18							20						
2	3	4	5	6	2	3	4	5	6	7	2	3	4	5	6	7	8	2	3	4	5	6	7	8
5/32	5/32	5/32	5/32	5/32	5/32	5/32	5/32	5/32	5/32	3/16	3/16	3/16	3/16	3/16	3/16	3/16	7/32	3/16	3/16	3/16	3/16	3/16	3/16	7/32
1/4	9/32	5/16	11/32	3/8	1/4	9/32	5/16	11/32	3/8	7/16	9/32	5/16	11/32	3/8	13/32	7/16	1/2	9/32	3/16	11/32	3/8	13/32	7/16	1/2
7/8	7/8	1	1 1/8	1 1/4	1	1	1 1/8	1 1/4	1 1/4	1 1/2	1	1	1 1/8	1 1/4	1 1/2	1 1/2	1 3/4	1	1	1 1/8	1 1/4	1 1/2	1 1/2	1 3/4
3/8	3/8	7/16	1/2	9/16	7/16	7/16	1/2	9/16	9/16	11/16	7/16	7/16	1/2	9/16	11/16	11/16	3/4	7/16	7/16	1/2	9/16	11/16	11/16	3/4
11/16	11/16	11/16	3/4	3/4	11/16	11/16	3/4	3/4	13/16	13/16	11/16	11/16	3/4	3/4	13/16	13/16	7/8	11/16	11/16	3/4	3/4	13/16	13/16	7/8
1 3/4	2 1/4	2 3/4	3 1/2	4 1/2	1 3/4	2 1/4	2 3/4	3 1/2	4 1/2	5 1/4	1 3/4	2 1/2	3 1/2	4 1/4	5 1/4	6	7	1 3/4	2 1/2	3 1/2	4 1/4	5 1/4	6	7

26				28							0							32						
6	7	8	9	3	4	5	6	7	8	9	3	4	5	6	7	8	9	3	4	5	6	7	8	9
7/32	7/32	1/4	1/4	7/32	7/32	7/32	7/32	1/4	1/4	1/4	7/32	7/32	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	9/32	9/32
7/16	15/16	17/32	9/16	11/32	3/8	13/32	7/16	1/2	17/32	9/16	11/32	3/8	7/16	15/32	1/2	17/32	9/16	3/8	13/32	7/16	15/32	1/2	9/16	5/8
1 1/2	1 3/4	1 7/8	1 7/8	1 1/4	1 1/4	1 1/2	1 1/2	1 3/4	1 7/8	2	1 1/4	1 1/4	1 1/2	1 1/2	1 3/4	1 7/8	2	1 1/4	1 1/2	1 1/2	1 3/4	1 7/8	2	2
11/16	3/4	13/16	13/16	9/16	9/16	11/16	11/16	3/4	13/16	7/8	9/16	9/16	11/16	11/16	3/4	13/16	7/8	9/16	11/16	11/16	3/4	13/16	7/8	7/8
7/8	15/16	13/16	1	7/8	7/8	15/16	15/16	1	1	1 1/8	15/16	15/16	1	1	1 1/8	1 1/8	1 1/4	15/16	15/16	1	1	1 1/8	1 1/8	1 3/4
5 1/4	6	7	8	2 3/4	3 1/2	4 1/2	5 1/4	6	7	8	2 3/4	3 1/2	4 1/2	5 1/4	6	7	8	2 3/4	3 1/2	4 1/2	5 1/4	6	7	8



Steel pulleys can be run at higher speeds than cast iron as they are stronger and lighter. Furthermore, tests have shown that belts slip less on steel than on cast iron or wood.

Steel pulleys are of split construction, no keys being required, the pulleys being held to the shaft by compression of hub by bolts.

Data on steel pulleys as manufactured by the American Steel Pulley Co., Philadelphia, Pa., are given on pages 122 and 123.

Wood pulleys are cheaper and lighter than cast iron, and under certain conditions give excellent service. They should not be run in damp places nor at high speeds. A wood rim of hard maple segments, properly laid up in glue, has nearly three times the strength of good cast iron for resisting the stresses set up by its own rotation.

The tractive pull of a leather belt upon a wood rim is greater than upon any metallic rim. With wood pulleys looser belts can be run, and belt slippage can be reduced to a minimum.

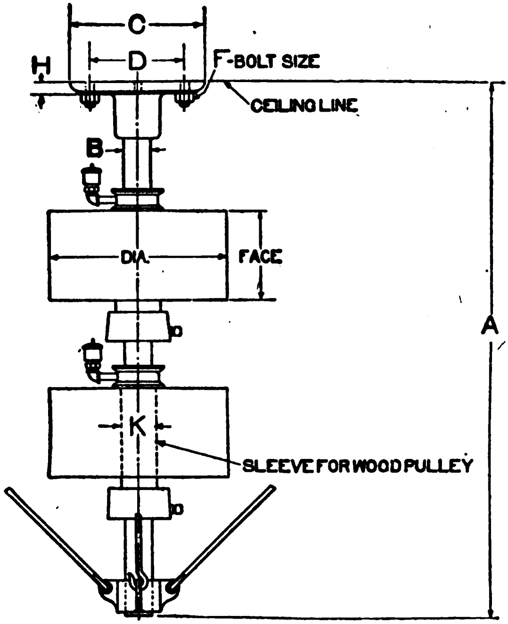
There are no standard dimensions as manufacturers have developed their own designs. Below are sizes manufactured by the Dodge Mfg. Co., Mishawaka, Ind.

Dia. of pulley	Dia. of shaft
3″	1½″
4″	2″
5″ to 7″	2$\frac{7}{16}$″
8″ " 23″	3″
24″ " 48″	3½″
50″ " 72″	4½″
72″ up to 12″ face	4½″
72″, 13″ face and wider	6″
73″ to 96″	6″
97″ " 120″	7½″

May be obtained in a variety of face widths—widths above 6 ins. advancing by two, as 6, 8, 10, 12, etc.

MULE STANDS

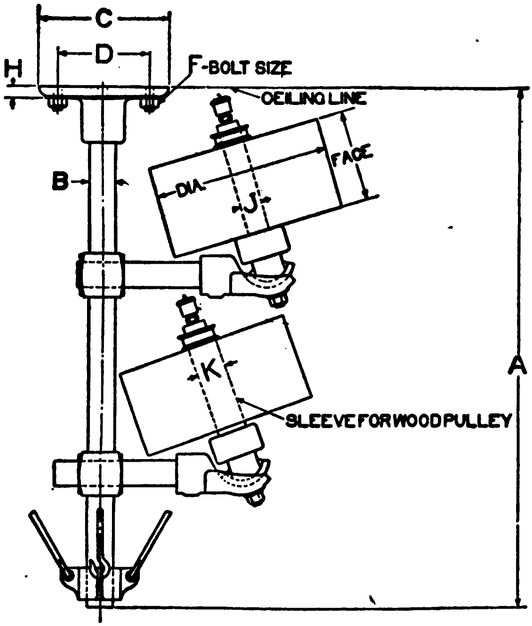
Stationary



Pulley Dia. x Face	A	B	C	D	F	H	K	Rods Dia. x Lth.
10 x 3	4′ 0″	$1\frac{15}{16}$	10	$8\frac{1}{16}$	$\frac{5}{8}$	1	3	$\frac{1}{4}$ x 5′ 6″
10 x 4	4′ 0″	$1\frac{15}{16}$	10	$8\frac{1}{16}$	$\frac{5}{8}$	1	3	$\frac{1}{4}$ x 5′ 6″
12 x 5	4′ 0″	$1\frac{15}{16}$	10	$8\frac{1}{16}$	$\frac{5}{8}$	1	3	$\frac{3}{8}$ x 5′ 6″
12 x 6	5′ 0″	$2\frac{7}{16}$	12	10	$\frac{3}{4}$	$1\frac{1}{8}$	$3\frac{1}{2}$	$\frac{3}{8}$ x 7′ 0″
12 x 7	5′ 0″	$2\frac{7}{16}$	12	10	$\frac{3}{4}$	$1\frac{1}{8}$	$3\frac{1}{2}$	$\frac{3}{8}$ x 7′ 0″
16 x 8	5′ 0″	$2\frac{7}{16}$	12	10	$\frac{3}{4}$	$1\frac{1}{8}$	$3\frac{1}{2}$	$\frac{1}{2}$ x 7′ 0″
24 x 10	6′ 0″	$2\frac{15}{16}$	$13\frac{7}{8}$	$11\frac{5}{8}$	$\frac{7}{8}$	$1\frac{1}{4}$	4	$\frac{1}{2}$ x 8′ 6″
24 x 12	6′ 0″	$2\frac{15}{16}$	$13\frac{7}{8}$	$11\frac{5}{8}$	$\frac{7}{8}$	$1\frac{1}{4}$	4	$\frac{5}{8}$ x 8′ 6″
30 x 14	6′ 0″	$2\frac{15}{16}$	$13\frac{7}{8}$	$11\frac{5}{8}$	$\frac{7}{8}$	$1\frac{1}{4}$	4	$\frac{5}{8}$ x 8′ 6″

[Dodge Sales & Eng'g Co., Mishawaka, Ind.]

Adjustable



Pulley Dia. x Face	A	B	C	D	F	H	J	K	Rods Dia. x Lth.
10 x 3	4′ 0″	1 15/16	10	8 1/16	5/8	1	1 11/16	2 7/16	3/8 x 5′ 6″
10 x 4	4′ 0″	1 15/16	10	8 1/16	5/8	1	1 11/16	2 7/16	3/8 x 5′ 6″
12 x 5	4′ 0″	1 15/16	10	8 1/16	5/8	1	1 11/16	2 7/16	1/2 x 5′ 6″
12 x 6	5′ 0″	2 7/16	12	10	3/4	1 1/8	1 15/16	3	1/2 x 7′ 0″
12 x 7	5′ 0″	2 7/16	12	10	3/4	1 1/8	1 15/16	3	1/2 x 7′ 0″
16 x 8	5′ 0″	2 7/16	12	10	3/4	1 1/8	1 15/16	3	5/8 x 7′ 0″
24 x 10	6′ 0″	2 15/16	13 7/8	11 5/8	7/8	1 1/4	2 7/16	3 1/2	5/8 x 8′ 6″
24 x 12	6′ 0″	2 15/16	13 7/8	11 5/8	7/8	1 1/4	2 7/16	3 1/2	3/4 x 8′ 6″
30 x 14	6′ 0″	2 15/16	13 7/8	11 5/8	7/8	1 1/4	2 7/16	3 1/2	3/4 x 8′ 6″

[Dodge Sales & Eng'g Co., Mishawaka, Ind.]

BELTING

Wide, thin belts are not as satisfactory as narrow thick ones. To get the best results shaft centers should be from 20 to 25 ft. apart. The most economical speeds for belts are from 4,000 to 4,500 ft. per min.

Leather Belts.—For high speeds, the leather should be cut along the spine of the hide, and for low across the shoulder.

Single leather belts are $\frac{7}{32}$ to $\frac{1}{4}$ inch thick, double $\frac{21}{64}$ to $\frac{23}{64}$.

Single belts for pulleys up to 11 ins. dia.
Double " " " from 12 ins. and up.
Triple " " " " 20 " " "

U. S. Navy specifications call for oak tanned single leather belts to have a tensile strength of 4,000 lbs. per sq. in., and double 3,600.

Commercial sizes—widths increase by $\frac{1}{8}$ inch up to 1 inch, $\frac{1}{4}$ inch up to 4, and $\frac{1}{2}$ inch to 7. Above 7 ins. depends on the manufacturer.

Rubber belts are made of duck saturated with rubber. They are particularly suited for running in damp places.

Rubber belts are often figured as averaging $\frac{1}{16}$ inch thickness per ply.

2 ply rubber belt	=	light	single	leather	belt.
3 " " "	=	medium	"	"	"
4 " " "	=	heavy	"	"	"
5 " " "	=	light	double	"	"
6 " " "	=	medium	"	"	"
7 " " "	=	heavy	"	"	"
8 " " "	=	triple	"	"	"

Commercial sizes

Ply	Width
2, 3 and 4	1 to 60 ins.
5	$1\frac{1}{2}$ " " "
6	2 " " "
7	4 " " "
8	6 " " "

Widths from 1 to 2 ins. increase by $\frac{1}{4}$ in., 2 to 5 by $\frac{1}{2}$, 5 to 16 by 1, and 16 to 60 by 2.

Canvas belts have about the same strength as leather.

Commercial sizes

Ply	Width
4	1½ to 18 ins.
6	3 " 30 "
8	4 " 48 "
10	12 " 60 "

Widths from 1½ to 5 ins. increase by ½ in., 5 to 14 by 1, from 14 to 32 by 2. Above 32 ins. special widths can be obtained from manufacturer.

Balata Belts.—These consist of a cotton fabric which is thoroughly impregnated with a solution, the chief ingredient of which is balata. Balata belts should not be installed where the temperature is over 120 degs. F., and they should be kept free from oil. The following table was furnished by R. & J. Dick Co., Passaic, N. J., manufacturers of balata belts.

The following table shows the horse power which each inch of width of belting, from 3 ply to 10 ply, will transmit at the speed given.

Speed of Belt per min.	3 Ply	4 Ply	5 Ply	6 Ply	7 Ply	8 Ply	9 Ply	10 Ply
Ft.	H. P.	H. P.	H. P.	H. P.	H. P.	H. P.	H. P.	H. P.
500	0.60	0.90	1.21	1.51	1.81	2.12	2.42	2.71
750	0.90	1.36	1.81	2.27	2.72	3.18	3.63	4.08
1000	1.21	1.81	2.42	3.03	3.63	4.24	4.84	5.44
1250	1.51	2.27	3.03	3.79	4.55	5.30	6.06	6.82
1500	1.81	2.72	3.63	4.55	5.45	6.36	7.27	8.17
1750	2.12	3.18	4.24	5.30	6.36	7.42	8.48	9.54
2000	2.42	3.63	4.85	6.06	7.27	8.48	9.70	10.90
2250	2.72	4.09	5.45	6.82	8.18	9.54	10.90	12.27
2500	3.03	4.54	6.06	7.58	9.10	10.60	12.12	13.64
2750	3.33	4.99	6.66	8.34	10.00	11.66	13.32	14.99
3000	3.63	5.44	7.26	9.10	10.90	12.72	14.52	16.34
3250	3.93	5.90	7.87	9.85	11.81	13.78	15.74	17.71
3500	4.24	6.36	8.48	10.60	12.72	14.84	17.96	19.08
3750	4.54	6.81	9.09	11.36	13.63	15.90	18.18	20.44
4000	4.84	7.27	9.70	12.12	14.54	16.96	19.40	21.81

Horse Power and Widths of Leather Belts.—Speed of belt in ft. per min. = .2618 × dia. of pulley in ins. × rev. per min.

The difference in tension in a belt when running, between the tight and the slack side for a single leather belt may be taken at 40 lbs. per inch of width, for a double belt 65 lbs. and triple 90.

To find H. P. a belt will transmit:

$$\text{H. P.} = \frac{\text{Speed in ft. per min.} \times \text{width in ins.} \times \text{tension in lbs.}}{33{,}000}$$

To find width of a belt to transmit a given H. P.:

$$\text{Width} = \frac{33{,}000 \times \text{H. P.}}{\text{Speed in ft. per min.} \times \text{tension in lbs.}}$$

Horse Power Table for Leather Belting

SINGLE BELTS

Speed in Feet per Minute	Width of Belt in Inches											
	2	3	4	5	6	8	10	12	14	16	18	20
	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.
400	1	1½	2	2½	3	4	5	6	7	8	9	10
600	1½	2¼	3	3¾	4½	6	7½	9	10½	12	13½	15
800	2	3	4	5	6	8	10	12	14	16	18	20
1000	2½	3¼	5	6¼	7½	10	12½	15	17½	20	22½	25
1200	3	4½	6	7½	9	12	15	18	21	24	27	30
1500	3¾	5¾	7½	9½	11½	15	18¾	22½	26½	30	33¾	37½
1800	4½	6¾	9	11¼	13½	18	22½	27	31½	36	40½	45
2000	5	7½	10	12½	15	20	25	30	35	40	45	50
2400	6	9	12	15	18	24	30	36	42	48	54	60
2800	7	10½	14	17½	21	28	35	42	49	56	63	70
3000	7½	11¼	15	18¾	22½	30	37½	45	52½	60	67½	75
3500	8¾	13	17½	22	26	35	44	52½	61	70	79	88
4000	10	15	20	25	30	40	50	60	70	80	90	100
4500	11¼	17	22½	28	34	45	57	69	78	90	102	114
5000	12½	19	25	31	37½	50	62½	75	87½	100	112	125

For double belts see page 124.

TABLE FOR CALCULATING HORSE POWERS WHICH MAY BE TRANSMITTED BY STEEL PULLEYS

Based on 180° Arc of Belt Contact and 125 Lbs. Pull per Inch Width of Face.
This Table Applies to Stock Pulleys. Am. Steel Pulley Co., Phila., Pa.

Dia. of Pulley in Inches	Faces of Pulleys in Inches																				Maximum R.P.M. Recommended 6000 ft. per min. (rim speed)
	2	3	4	5	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	
3	.006	.009	.012																		7636
4	.008	.012	.016	.020																	5727
5	.010	.015	.020	.025																	4581
6	.012	.018	.024	.030	.036																3818
7	.014	.021	.028	.035	.042																3272
8	.016	.024	.032	.040	.048	.064	.080														2863
9	.018	.027	.036	.045	.054	.072	.090														2545
10	.020	.030	.040	.050	.060	.080	.100	.120													2290
11	.022	.033	.044	.055	.066	.088	.110	.132													2082
12	.024	.036	.048	.060	.072	.096	.120	.144													1908
13	.026	.039	.052	.065	.078	.104	.130	.156													1761
14	.028	.042	.056	.070	.084	.112	.140	.168													1636
15	.030	.045	.060	.075	.090	.120	.150	.180													1527
16	.032	.048	.064	.080	.096	.128	.160	.192													1431
17		.051	.068	.085	.102	.136	.170	204													1347
18		.054	.072	.090	.108	.144	.180	.216													1272
19		.057	.076	.095	.114	.152	.190	.228													1205
20		.060	.080	.100	.120	.160	.200	.240													1145
21		.063	.084	.105	.126	.168	.210	.252	.294	.336											1090
22		.066	.088	.110	.132	.176	.220	.264	.308	.352											1041
23		.069	.092	115	.138	.184	.230	.276	.322	.368											996
24		.072	.096	.120	.144	.192	.240	.288	.336	.384	.432	.480									954
25			.100		.150	.200	.250	.300	.350	.400	.450	.500									916
26			.104		.156	.208	.260	.312	.364	.416	.468	.520									881
28			.108		.168	.224	.280	.336	.392	.448	.504	.560									818
30			.120		.180	.240	.300	.360	.420	.480	.540	.600	.660	.720	.780	.840	.900				763
32			.128		.192	.256	.320	.384	.448	.512	.576	.640	.704	.768	.832	.896	.960	1.024			715
34			.136		.204	.272	.340	.408	.476	.544	.612	.680	.748	.816	.884	.952	1.020	1.088			673
36			.144		.216	.288	.360	.432	.504	.576	.648	.720	.792	.864	.936	1.008	1.080	1.152	1.224	1.296	636
38			.152		.228	.304	.380	.456	.532	.618	.684	.760	.836	.912	.988	1.064	1.140	1.216	1.292	1.368	602
40			.160		.240	.320	.400	.480	.560	.640	.720	.800	.880	.960	1.040	1.120	1.200	1.280	1.360	1.440	572
42			.168		.252	.336	.420	.504	.588	.672	.756	.840	.924	1.008	1.092	1.176	1.260	1.344	1.428	1.512	545
44					.264	.352	.440	.528	.616	.704	.792	.880	.968	1.056	1.144	1.232	1.320	1.408	1.496	1.584	520
46					276	.368	.460	.552	.644	.736	.828	.920	1.012	1.104	1.196	1.288	1.380	1.472	1.564	1.656	497
48					.288	.384	.480	.576	.672	.768	.864	.960	1.056	1.152	1.248	1.344	1.440	1.536	1.632	1.728	477

50	....	....	....	....	.300	.400	.500	.600	.700	.800	.900	1.000	1.100	1.200	1.300	1.400	1.500	1.600	1.700	1.800	458
52	....	....	....	....	.312	.416	.520	.624	.728	.832	.936	1.040	1.144	1.248	1.352	1.456	1.560	1.664	1.768	1.872	440
54	....	....	....	....	.324	.432	.540	.648	.756	.864	.972	1.080	1.188	1.296	1.404	1.512	1.620	1.728	1.836	1.944	424
56	....	....	....	....	.336	.448	.560	.672	.784	.896	1.008	1.120	1.232	1.344	1.456	1.568	1.680	1.792	1.904	2.016	409
58	....	....	....	....	.348	.464	.580	.696	.812	.928	1.044	1.160	1.160	1.392	1.508	1.624	1.740	1.856	1.972	2.088	394
60	....	....	....	....	.360	.480	.600	.720	.840	.960	1.080	1.200	1.320	1.440	1.560	1.680	1.800	1.920	2.040	2.160	381
62	....	....	....	....	.372	.496	.620	.744	.868	.992	1.116	1.240	1.364	1.488	1.612	1.736	1.860	1.984	2.108	2.232	369
64	....	....	....	....	.384	.512	.640	.768	.896	1.024	1.152	1.280	1.408	1.536	1.664	1.792	1.920	2.048	2.176	2.304	357
66	....	....	....	....	.396	.528	.660	.792	.924	1.056	1.188	1.320	1.452	1.584	1.716	1.848	1.980	2.112	2.244	2.376	347
68	....	....	....	....	.408	.544	.680	.816	.952	1.088	1.224	1.360	1.496	1.632	1.768	1.904	2.040	2.176	2.312	2.448	336
70	....	....	....	....	.420	.560	.700	.840	.980	1.120	1.260	1.400	1.540	1.680	1.820	1.960	2.100	2.240	2.380	2.520	327
72	....	....	....	....	.432	.576	.720	.864	1.008	1.152	1.296	1.440	1.584	1.728	1.872	2.016	2.160	2.304	2.448	2.592	318
74	....	....	....	....	....	.592	.740	.888	1.036	1.184	1.332	1.480	1.628	1.776	1.924	2.072	2.220	2.368	2.516	2.664	309
76	....	....	....	....	....	.608	.760	.912	1.064	1.216	1.368	1.520	1.672	1.824	1.976	2.128	2.280	2.432	2.584	2.736	301
78	....	....	....	....	....	.624	.780	.936	1.092	1.248	1.404	1.560	1.716	1.872	2.028	2.184	2.340	2.496	2.652	2.808	293
80	....	....	....	....	....	.640	.800	.960	1.120	1.280	1.440	1.600	1.760	1.920	2.080	2.240	2.400	2.560	2.720	2.880	286
82	....	....	....	....	....	.656	.820	.984	1.148	1.312	1.476	1.640	1.804	1.968	2.132	2.296	2.460	2.624	2.788	2.952	279
84	....	....	....	....	....	.672	.840	1.008	1.176	1.344	1.512	1.680	1.848	2.016	2.184	2.352	2.520	2.688	2.856	3.024	272
86	....	....	....	....	....	.688	.860	1.032	1.204	1.376	1.548	1.720	1.892	2.064	2.236	2.408	2.580	2.752	2.924	3.096	266
88	....	....	....	....	....	.704	.880	1.066	1.232	1.408	1.584	1.760	1.936	2.112	2.288	2.464	2.640	2.816	2.992	3.168	260
90	....	....	....	....	....	....	.900	1.080	1.260	1.440	1.620	1.800	1.980	2.160	2.340	2.520	2.700	2.880	3.060	3.240	254
92	....	....	....	....	....	....	.920	1.104	1.288	1.472	1.656	1.840	1.024	2.208	2.392	2.576	2.760	2.944	3.128	3.312	249
94	....	....	....	....	....	....	.940	1.128	1.316	1.504	1.692	1.880	2.068	2.256	2.444	2.632	2.820	2.008	3.196	3.384	243
96	....	....	....	....	....	....	.960	1.152	1.344	1.536	1.728	1.920	2.112	2.304	2.496	2.688	2.880	3.072	3.264	3.456	238
98	....	....	....	....	....	....	.980	1.176	1.372	1.568	1.764	1.960	2.156	2.352	2.548	2.744	2.940	3.136	3.332	3.528	233
100	....	....	....	....	....	....	1.000	1.200	1.400	1.600	1.800	2.000	2.200	2.400	2.600	2.800	3.000	3.200	3.400	3.600	229
102	....	....	....	....	....	....	1.020	1.224	1.428	1.632	1.836	2.040	2.244	2.448	2.652	2.856	3.060	3.264	3.468	3.672	224
104	....	....	....	....	....	....	1.040	1.248	1.456	1.664	1.872	2.080	2.288	2.496	2.704	2.912	3.120	3.328	3.536	3.744	221
106	....	....	....	....	....	....	1.060	1.272	1.484	1.696	1.908	2.120	2.332	2.544	2.756	2.968	3.180	3.392	3.604	3.816	216
108	....	....	....	....	....	....	1.080	1.296	1.512	1.728	1.944	2.160	2.376	2.592	2.808	3.024	3.240	3.456	3.672	3.888	212
110	....	....	....	....	....	....	1.100	1.320	1.540	1.760	1.980	2.200	2.420	2.640	2.860	3.080	3.300	3.520	3.740	3.960	208
112	....	....	....	....	....	....	1.120	1.344	1.568	1.792	2.016	2.240	2.464	2.688	2.912	3.136	3.360	3.584	3.808	4.032	204
114	....	....	....	....	....	....	....	1.368	1.596	1.824	2.052	2.280	2.508	2.736	2.964	3.192	3.420	3.648	3.876	4.104	200
116	....	....	....	....	....	....	....	1.392	1.624	1.856	2.088	2.320	2.552	2.784	3.016	3.248	3.480	3.712	3.944	4.176	197
118	....	....	....	....	....	....	....	1.416	1.652	1.888	2.124	2.360	2.596	2.832	3.068	3.304	3.540	3.776	4.012	4.248	194
120	....	....	....	....	....	....	....	1.440	1.680	1.920	2.160	2.400	2.640	2.880	3.120	3.360	3.600	3.840	4.080	4.320	190

To find horse power a given pulley will transmit, multiply number of revolutions per minute by number in table opposite size of pulley; multiply result by 3.5 for a normal belt pull of 75 lbs. per inch width of pulley face—or

R. P. M. × NO. (From Table) = Horse Power (At 125 lbs. Per Inch Width of Belt) (Multiply result by 3.5 for a normal belt pull of 75 lbs. per inch width of pulley face)

To find revolutions per minute necessary for a given pulley to transmit a given horse power, divide H. P. by number opposite size of pulley; multiply result by 1.66 for a normal belt pull of 75 lbs. per inch width of pulley face—or

H. P. ÷ NO (Form Table) = Rev. per Min. (At 125 lbs. Per Inch Width of Belt) (Multiply result by 1.66 for a normal belt pull of 75 lbs. per inch width of pulley face)

Note—All Figures are for Double Belt

Double Belts

(*Continued from page 121.*)

Speed in Feet per Minute	Width of Belt in Inches										
	4	6	8	10	12	14	16	18	20	22	24
	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.
400	2¾	4¼	5¾	7¼	8½	10	11½	13	14½	16	17½
600	4¼	6½	8¾	11	13	15	17½	19½	22	24	26
800	5¾	8½	11½	14½	17½	20½	23	26	29	32	34½
1000	7¼	11	14½	18¼	21½	25½	29	32½	36	40	43½
1200	8½	13	17½	22	26	30½	34½	39	44	48	52½
1500	10¾	16¼	21¾	27¼	32½	38	43½	49	54½	60	65½
1800	13	19½	26	32¾	39	45½	52	59	65½	72	78½
2000	14½	21¾	29	36½	43½	50½	58	65½	72½	80	87
2400	17¼	26	34¾	44	52½	60½	69½	78½	88	96	105
2800	20¼	30½	40½	51	61	71	81	91½	102	112	122
3000	21½	32½	43½	54½	65½	76	87½	98	108	120	131
3500	25½	38	50¾	63½	76	89	101	114	127	140	153
4000	29	43½	58¼	72¾	87	101	116	131	145	160	174
4500	32½	49	65	82	98	114	131	147	163	180	196
5000	36½	54½	72¾	91	109	127	145	163	182	200	218

[Foote Bros. Gear & Mach. Co., Chicago]

For single belts see page 121.

Length of Belt for a Given Drive

C = distance between centers of pulleys.
R = radius of large pulley.
r = " " small "
A = arc of contact of large pulley.
B = " " " " small "

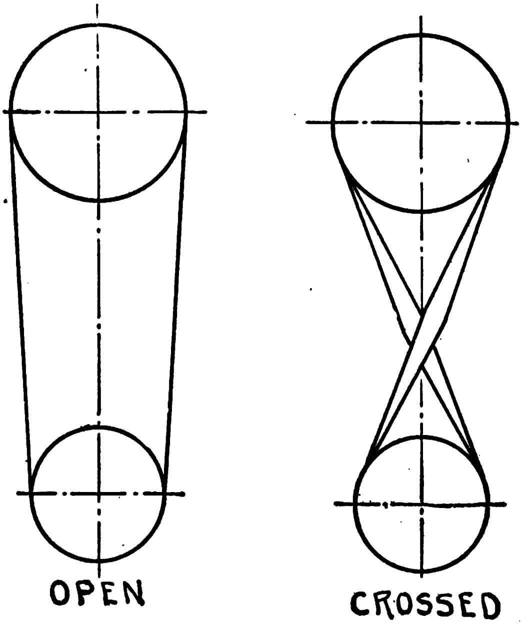
Length of open belt $= A + B + 2\sqrt{C^2 - (R - r)^2}$
" " crossed belt $= A + B + 2\sqrt{C^2 - (R + r)^2}$

BELT DRIVES

Power may be lost by journal friction and belt slipping. To prevent the former the belt should not be run too tight. As to belt slipping, this may be largely overcome by applying a dressing.

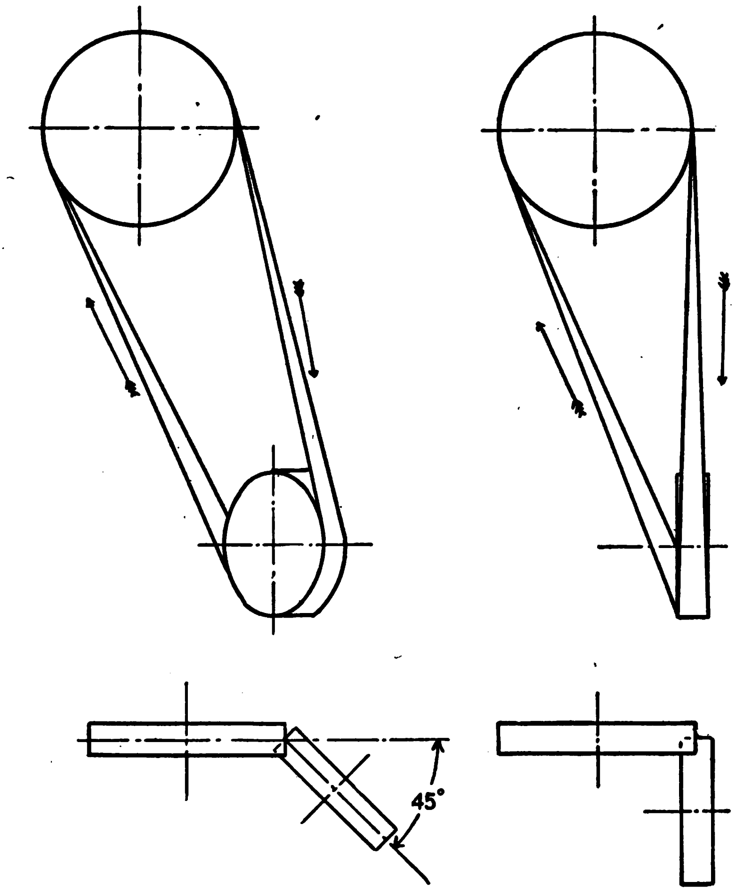
Shafts with Parallel Axes.—Here the center line of the driving and following sides of the belt fall in the middle planes of both

pulleys—hence the belt can run in either direction. The arc of contact of crossed belts is equal on both pulleys and is always more than 180 degrees. The gain in contact is lost by the twist in the belt, which causes it to run unevenly on the pulley. However, the arc is generally taken at 180 degrees in making calculations.



Shafts in Parallel Planes but Inclined to Each Other.—The center line of the driving side of the belt is in the middle plane of both pulleys, but the following side is not—thus the belt can run in one direction only.

Shafts with Inclined Axes.—A and B (page 127) are the centers of two pulleys, θ being the angle between their planes A x y and B x y. Any two points as x and y are taken on the line of inter-

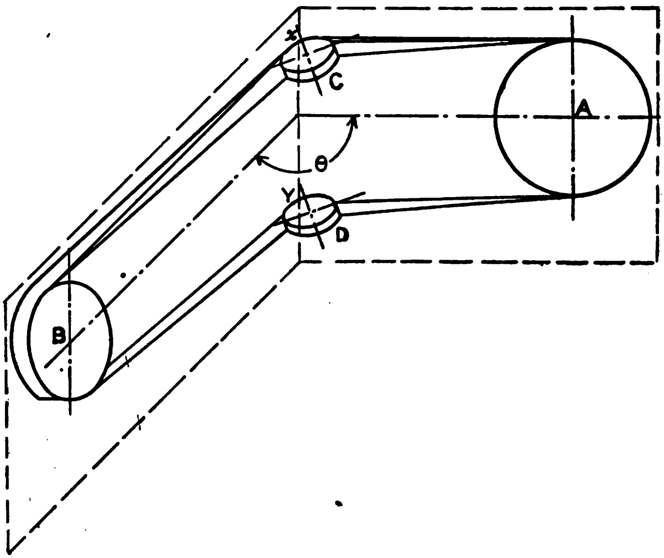


QUARTER TURN HALF TURN

section x y of the planes, and tangents drawn to the pulleys A and B. The center circles of the guide pulleys C and D must be tangent to the tangents drawn from x and y, to the pulleys A and B.

BELT DRIVE WITH SHAFTS AT INCLINED AXES

(See page 125.)

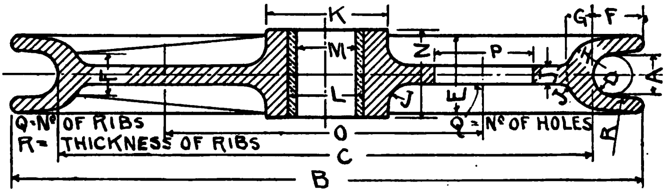


ROPE DRIVES

Transmission rope is made from hemp or manila fibres with 3, 4 or 6 strands, the 3 strands for small drives and the 4 and 6 for large drives. A table of 4-strand manila rope is given on page 129.

WIRE ROPE SHEAVES (Cast Iron)

(See next page for table.)



ROPE SHEAVES AND PULLEYS (See page 127.)

A	B	C	D	E	F	G	H	J	K	L	M	N	O	P	Q	R	Wt.
3/8	5	4 1/16	7/32	3/4	15/32	9/32	11/32	3/16	1 1/4	13/16	9/16	7/8	2 3/8	5/8	4	5/32	1.7
"	6	5 1/16	"	"	"	"	"	"	"	"	"	"	3	1	4	"	2.2
"	7	6 1/16	"	"	"	"	"	"	"	"	"	"	3 1/2	1 1/4	4	"	2.8
"	8	7 1/16	"	"	"	"	"	"	"	"	"	"	4	1 1/2	4	"	3.5
1/2	6	4 3/4	9/32	1	5/8	3/8	15/32	1/4	1 1/2	1	3/4	1 1/8	2 3/4	3/4	4	3/16	3.3
"	7	5 3/4	"	"	"	"	"	"	"	"	"	"	3 1/4	1	4	"	4.2
"	8	6 3/4	"	"	"	"	"	"	"	"	"	"	3 3/4	1 1/4	4	"	5.1
"	10	8 3/4	"	"	"	"	"	"	"	"	"	"	5	2	4	"	7.1
"	12	10 3/4	"	"	"	"	"	"	"	"	"	"	6 3/4	2 1/4	5	"	9.7
5/8	8	6 7/16	11/32	1 1/4	25/32	15/32	19/32	5/16	1 7/8	1 1/4	15/16	1 3/8	3 3/4	1	4	1/4	7.2
"	10	8 7/16	"	"	"	"	"	"	"	"	"	"	4 3/4	1 3/4	4	"	9.9
"	12	10 7/16	"	"	"	"	"	"	"	"	"	"	6 1/2	2 1/8	5	"	13
"	14	12 7/16	"	"	"	"	"	"	"	"	"	"	7 1/2	2 1/2	5	"	17
"	16	14 7/16	"	"	"	"	"	"	"	"	"	"	8 3/4	3 1/8	5	"	21
3/4	10	8 1/8	7/16	1 1/2	15/16	9/16	11/16	3/8	2 1/4	1 1/2	1 1/8	1 11/16	4 3/4	1 1/2	4	9/32	13
"	12	10 1/8	"	"	"	"	"	"	"	"	"	"	6 1/4	1 7/8	5	"	17
"	14	12 1/8	"	"	"	"	"	"	"	"	"	"	7	2 1/4	5	"	22
"	16	14 1/8	"	"	"	"	"	"	"	"	"	"	8 1/2	3	5	"	27
"	18	16 1/8	"	"	"	"	"	"	"	"	"	"	10 1/4	3	6	"	34
"	20	18 1/8	"	"	"	"	"	"	"	"	"	"	11 1/2	3 1/4	6	"	41
7/8	12	9 13/16	1/2	1 3/4	1 3/32	21/32	13/16	7/16	2 5/8	1 11/16	1 5/16	2	5 3/4	1 5/8	5	11/32	22
"	14	11 13/16	"	"	"	"	"	"	"	"	"	"	6 3/4	2 1/8	5	"	28
"	16	13 13/16	"	"	"	"	"	"	"	"	"	"	8 1/4	2 3/4	5	"	34
"	18	15 13/16	"	"	"	"	"	"	"	"	"	"	10	2 7/8	6	"	42
"	20	17 13/16	"	"	"	"	"	"	"	"	"	"	11	3 1/8	6	"	50
"	24	21 13/16	"	"	"	"	"	"	"	"	"	"	14	4 1/4	6	"	66
1	14	11 1/2	9/16	2	1 1/4	3/4	15/16	1/2	3	1 7/8	1 1/2	2 1/4	6 1/2	2	5	3/8	34
"	16	13 1/2	"	"	"	"	"	"	"	"	"	"	8	2 1/2	5	"	41
"	18	15 1/2	"	"	"	"	"	"	"	"	"	"	9 1/2	2 5/8	6	"	50
"	20	17 1/2	"	"	"	"	"	"	"	"	"	"	10 3/4	3	6	"	59
"	24	21 1/2	"	"	"	"	"	"	"	"	"	"	13 1/2	4	6	"	79
1 1/8	18	15 3/16	5/8	2 1/4	1 13/32	27/32	1 1/16	9/16	3 3/8	2 1/16	1 11/16	2 1/2	9 1/4	2 1/2	6	7/16	60
"	20	17 3/16	"	"	"	"	"	"	"	"	"	"	10 1/2	2 7/8	6	"	71
"	24	21 3/16	"	"	"	"	"	"	"	"	"	"	13	3 3/4	6	"	95
1 1/4	20	16 7/8	11/16	2 1/2	1 9/16	15/16	1 5/32	5/8	3 3/4	2 1/4	1 7/8	2 3/4	10 1/4	2 3/4	6	15/32	82
"	24	20 7/8	"	"	"	"	"	"	"	"	"	"	12 1/2	3 1/2	6	...	110

[Upson-Walton Co., Cleveland, O.]

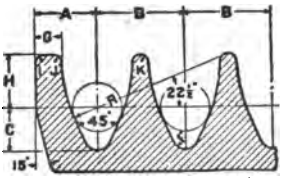
MANILA TRANSMISSION ROPE

Dia. of rope ins.	W't per ft.	Breaking strength lbs.	Length req'd for splice ft.	Smallest dia. of sheave	Dia. of rope ins.	Weight per ft.	Breaking strength lbs.	Length req'd for splice ft.	Smallest dia. of sheave
¾	.20	4500	8	28	1⅜	.65	15125	12	50
⅞	.26	6125	8	32	1½	.77	18000	12	54
1	.34	8000	10	36	1⅝	.90	21125	12	60
1⅛	.43	10125	10	40	1¾	1.04	24500	12	64
1¼	.53	12500	10	46	2	1.36	32000	14	72

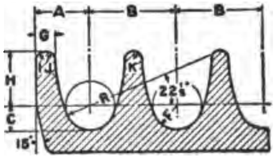
[T. B. Wood's Sons Co., Chambersburg, Pa.]

American system of rope transmission has one continuous rope winding from one groove or sheave to another. In this system a uniform tension is kept on the rope, by a traveling tension carriage.

DODGE STANDARD 60° V AND U GROOVES
FOR AMERICAN SYSTEM ROPE TRANSMISSION



V Groove

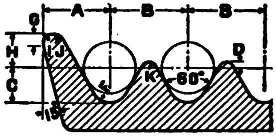


U Groove

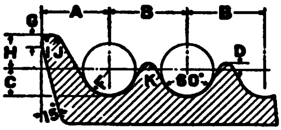
Rope Size	A	B	C		D	F		G	H	I	J	K
			V Gr.	U Gr.		V Gr.	U Gr.					
¾	1	1¼	9/16	⅜	⅛	3/16	⅜	3/16	½	1/16	⅛	7/32
⅞	1⅛	1⅜	⅝	7/16	⅛	¼	7/16	3/16	9/16	1/16	⅛	3/16
1	1¼	1½	11/16	½	⅛	5/16	½	3/16	⅝	1/16	⅛	5/32
1⅛	1⅜	1⅝	¾	9/16	⅛	⅜	9/16	3/16	11/16	⅛	3/16	5/32
1¼	1½	1¾	13/16	⅝	⅛	7/16	⅝	¼	¾	⅛	3/16	5/32
1⅜	1⅝	1⅞	⅞	11/16	⅛	½	11/16	5/16	13/16	⅛	3/16	⅛
1½	1¾	2	1	¾	⅛	½	¾	5/16	13/16	⅛	¼	3/32
1¾	2	2½	1⅛	⅞	3/16	⅝	⅞	7/16	15/16	⅛	¼	7/32
2	2¼	2¾	1¼	1	3/16	¾	1	7/16	1 1/16	⅛	¼	3/16

In the English or separate warp system, a single endless rope is required for each groove or sheave. The English system is now little used except in main drives, as from engine to countershaft.

Engineers' Standard V and U Grooves For English System Rope Transmission



V Groove



U Groove

Rope Size	A*		B	C		F		G*		H	I	J K
	V Gr.	U Gr.		V Gr.	U Gr.	V Gr.	U Gr.	V Gr.	U Gr.			
3/4	15/16	7/8	1 3/8	5/8	3/8	7/32	3/8	3/8	5/16	13/16	1/8	1/8
7/8	1 1/16	15/16	1 1/2	11/16	7/16	9/32	7/16	7/16	5/16	7/8	1/8	1/8
1	1 5/16	1 3/16	1 7/8	7/8	1/2	17/64	1/2	9/16	7/16	1 3/16	3/16	3/16
1 1/8	1 3/8	1 1/4	2	15/16	9/16	11/32	9/16	9/16	7/16	1 1/4	3/16	3/16
1 1/4	1 1/2	1 5/16	2 1/8	1 1/16	5/8	11/32	5/8	5/8	7/16	1 5/16	3/16	3/16
1 3/8	1 9/16	1 3/8	2 1/8	1 1/4	11/16	11/32	11/16	11/16	1/2	1 3/8	3/16	3/16
1 1/2	1 11/16	1 1/2	2 1/4	1 3/8	3/4	3/8	3/4	3/4	9/16	1 9/16	3/16	3/16
1 3/4	1 15/16	1 3/4	2 1/2	1 9/16	7/8	7/16	7/8	7/8	11/16	1 11/16	3/16	3/16
2	2 1/8	1 15/16	2 3/4	1 9/16	1	21/32	1	15/16	3/4	1 11/16	3/16	3/16

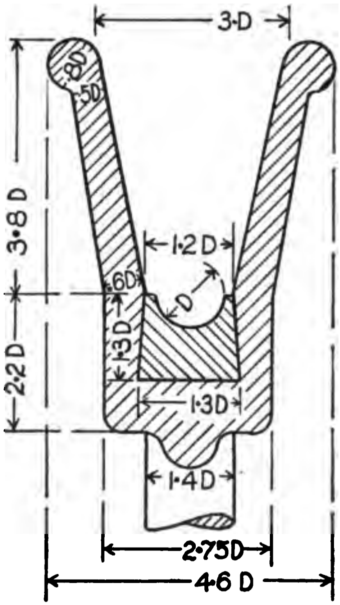
* A and G dimensions for ONE V Groove same as for U Grooves.

[Dodge Sales & Eng'g Co., Mishawaka, Ind.]

Wire rope may also be used for drives. The average speed for wire and manila rope is 4500 ft. per min.

The larger the sheaves, the lower is the operating cost as the rope wears longer. A single sheave with a filler is not suitable for transmitting more than 300 H.P., hence it is often necessary to have pulleys with a number of grooves. U grooves are preferable for outdoor service. When the distance between the driving and the driven pulley exceeds 150 ft. an idler should be installed.

Wire Rope Pulley for Power Transmission



D = diameter of rope in inches.

Number of arms, 6 for pulleys 2 to 4 ft. dia., 8 from 5 to 8 ft.

Arms have elliptic cross section, short dia. given in figure, long dia. 1.5 times short.

Pulley of cast iron, rope runs on a leather filler.

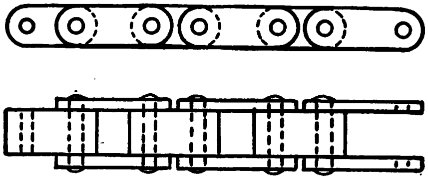
Diameter of pulley not less than 36 D.

Length of hub 2 to 2½ times dia. of shaft.

If a pulley with wider sides is required have the angle between the sides 60 degs. and the grooves for the rubber 30 degs.

CHAINS FOR TRANSMITTING POWER

Block Chains are for small power drives where the speed is from 600 to 800 ft. per min.



Sizes of Block Chain

The letters in the table refer to sprocket wheel on page 135.

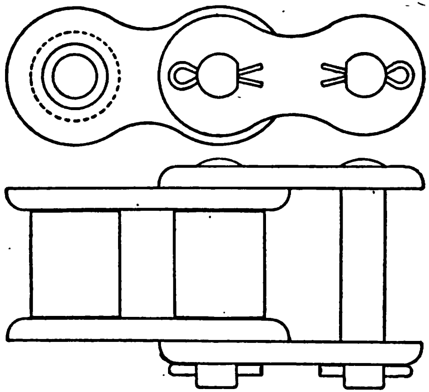
Chain Number	Pitch	Dia. of block	H. P.		Max. R. P. M.	Pull lbs.		Wt. per ft. lbs.	L	H	C	E	T	R
			Normal	Max.		Normal	Max.							
102 x 1/4	1"	.325"	1.1	3.4	2135	45	135	.33	.493	.380	3/16	.056	15/64	21/64
5/16	"	"	1.4	4.0	2225	56	160	.38	.595	"	"	"	9/32	"
3/8	"	"	1.7	4.5	2318	68	180	.42	.658	"	"	"	11/32	"
1/2	"	"	2.3	5.0	2453	92	200	.50	.783	"	"	"	15/32	"
105 x 1/2	1 1/2	.532	3.3	9.9	1213	133	398	.89	.898	.534	19/64	.09	29/64	17/32
5/8	"	"	4.1	12.4	1261	166	497	1.03	1.02	"	"	"	37/64	"

In the column Chain Number—the second number as 1/4, 5/16, etc. is the width of the chain.

[Diamond Chain & Mfg. Co., Indianapolis, Ind.]

Roller Chains

Roller Chains are for heavier loads than block and for speeds of 800 to 1,200 ft. per min.



Referring to the figure, a roller and pin are shown in the center, at the left a roller and at right a pin. A chain is made up of rollers and pins (as the center in the figure) with alternate in and out links.

Roller Chains for Transmitting Power

Sizes Recommended by Soc. of Automotive Engineers and Am. Soc. of Mechanical Engineers

Chain Number	Pitch	Dia. of roller	H. P. Normal	H. P. Max.	Max. R. P. M.	Pull lbs. Normal	Pull lbs. Max.	Wt. per ft. lbs.	L	H	*C	E	T	R
66 x 5/16	1/2	.306	....	....	....	....	...	.....	.....	....	...	....	...	..
149 x 3/8	5/8	.400	2.7	8.1	1993	108	325	.619	.822	.551	3/16	.056	11/32	11/32
153 x 1/2	3/4	.469	3.8	11.0	1608	147	442	.86	1.063	.612	.225	.068	15/32	13/32
154 x 5/8	1	.625	7.3	22.0	929	292	877	1.81	1.45	.82	19/64	.09	9/16	17/32
160 x 3/4	1 1/4	.75	9.9	29.7	640	396	1189	2.69	1.73	1.18	3/8	.113	11/16	11/16
162 x 1	1 1/2	.875	15.7	47.2	500	629	1888	4.15	2.20	1.40	29/64	.135	15/16	13/16
164 x 1	1 3/4	1.000	18.0	54.0	388	720	2160	4.96	2.24	1.65	17/32	5/32	29/32	61/64
168 x 1 1/4	2	1.125	24.4	73.1	334	975	2925	6.32	2.65	1.90	19/32	.180	1 5/32	1 3/32
....	2 1/2	1.562	....	....	....	....	...	.....	.....	....	...	....	...	..

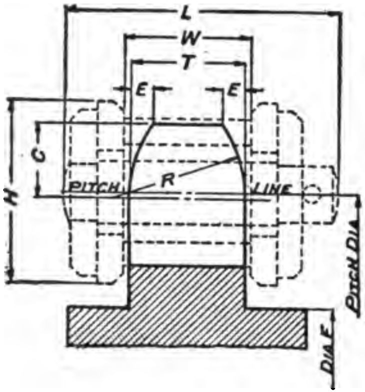
[Diamond Chain & Mfg. Co., Indianapolis, Ind.] Letters L, H, etc., refer to wheel, page 135.

The normal pull given in the table corresponds to a pressure of 1,000 lbs. per sq. in. of projected rivet area. The maximum pull is about three times the normal pull, but does not exceed one-tenth of the ultimate strength of the chain.

The projected rivet area for any chain may be found by dividing the number representing the normal pull by 1,000. For example, the normal pull for chain 160 x 3/4 is 396 lbs., and the projected rivet area is .396 sq. ins. Projected rivet area is the product of the rivet diameter and the length of the bushing in which the rivet turns.

The normal horse power given in the table corresponds to the normal pull at a chain speed of 800 ft. per min. The maximum horse power given is the maximum only when the chain pull does not exceed the limit given in the sixth column of table on page 134.

Sprocket teeth cross sections are given in columns C, E, T and R. F in the figure is the diameter of the rim or hub. It should not exceed pitch diameter minus 1.1 × H as clearance must be allowed for the side bars of the chain.



Silent Link.—The Morse Chain, page 137, (Morse Chain Co., Ithaca, N. Y.), is an example of this type. The important feature is the rocker joint, one of the pins being the seat pin and the other the rocker. The manufacturer's claim, 1st, positive speed ratio between driving and driven shafts with the added feature of flexibility, 2nd, 98½ to 99% sustained efficiency, 3rd, quietness at high speeds and 4th, long life.

Data to be Used in the Design of Morse Chains

Pitch, inches	3/8	1/2	5/8	3/4	9/10	1 2/10	1 1/2	2	3
Minimum number of teeth:									
Small sprocket driver	13	13	13	13	15	15	17	17	17
Small sprocket driven	13	17	17	21	25	29	29	31	35
Desirable number of teeth in driver sprockets	15–17	15–17	17–21	17–21	17–23	17–23	17–27	17–31	19–31
Maximum number of teeth in sprockets. (See Note 3)	75	99	109	115	125	129	129	129	131
Desirable number of teeth in driven sprockets	35–45	55–75	55–75	55–85	55–95	55–105	55–115	55–115	55–115
To find pitch diameter of wheel multiply number of teeth by (inches)	0.1193	0.159	0.199	0.239	0.2865	0.382	0.477	0.636	0.955
Addendum. For outside diameter of sprockets 33 to 130 T. (See Note 1) inches	.....	0.05	0.06	0.075	0.09	0.12	0.15	0.20	0.30
Maximum R. P. M	6,000	2,400	1,800	1,200	1,100	800	600	400	250
Radial clearance beyond tooth required for chain, inches	0.375	0.50	0.62	0.75	0.90	1.2	1.5	2.0	3.0
Tension per inch width chain, pounds:									
Small sprocket driver	60	80	100	120	150	200	270	450	750
Small sprocket driven	60	65	80	95	120	160	210	350	600
Approximate weight of chain per inch width, 1 foot long, pounds	0.75	1.00	1.25	1.50	1.80	2.40	3.00	4.00	6.00
C for solid pinions	0.003	0.0045	0.0063	0.009	0.013	0.023	0.035	0.058	0.145
C for armed sprockets	0.10	0.16	0.25	0.35	0.45	0.7	1.0	2.0	4.0

Note 1.—Number of teeth = T.
Exact outside diameter = D.
When T has less than 33 teeth, D = pitch diameter.
When T has more than 32 teeth, D = pitch diameter + (2 × addendum).

Note 2.—Use sprockets having an odd number of teeth whenever possible.

Note 3.—When specially authorised, a larger number of teeth than shown may be cut in large sprocket.

Note 4.—Thickness of sprocket rim, including teeth should be at least 1.2 times the chain pitch.

Note 5.—The number of grooves in the sprocket, their width and distance apart varies according to pitch and width of chain.

Note 6.—The width of the sprocket should be ⅛ to ¼ inch greater than nominal width of the chain.

Note 7.—An even number of links in the chain and an odd number of teeth in the wheels are desirable.

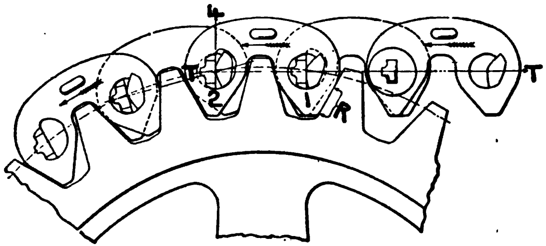
Note 8.—Horizontal drives preferred; tight chain on top desirable for short drives without center adjustment.

Note 9.—Adjustable wheel centers desirable for horizontal drives and necessary for vertical drives.

Note 10.—Avoid vertical drives.

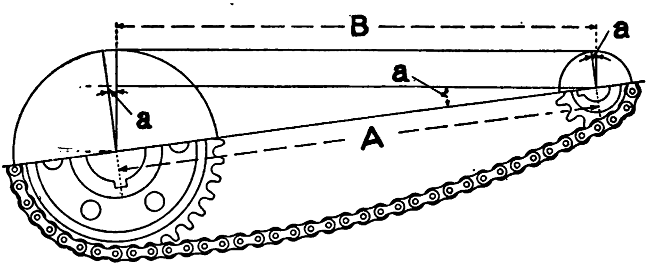
Note 11.—Allow a side clearance for chain (parallel to axis of sprockets and measured from nominal width of chain) equal to the pitch.

Note 12.—Maximum linear velocity for commercial service 1200 to 1600 feet per minute.



Referring to the figure the link contact with the teeth is resisted at R which is below the line of tension T T, while the resultant force F due to the lever action tends to maintain the chain link at its true pitch diameter while in contact with the wheel. The rolling action is shown by the two positions of the joint pins at 1 and 2.

Length of Chain



N = number of teeth on large sprocket
n = " " " " small "
R = radius of large sprocket, ins.
r = " " small " "
P = pitch of chain, ins.
A = distance between centers in pitches.
B = A cos a

$$\text{Chain lengths in pitches} = 2\,A + \frac{N+n}{2} + \frac{\left(\frac{N-n}{2\,n}\right)^2}{c}$$

$$= 2\,A + \frac{N+n}{2} + \frac{.0257\,(N-n)^2}{c}$$

If the chain length in pitches comes a fractional part of a pitch, use the next whole number. The length of chain in inches is equal to the product of the number of pitches by the pitch.

$$\text{Chain length in inches} = NP\left(\frac{180^\circ + 2a}{360^\circ}\right) + nP\left(\frac{180^\circ - 2a}{360^\circ}\right) + 2A\cos a$$

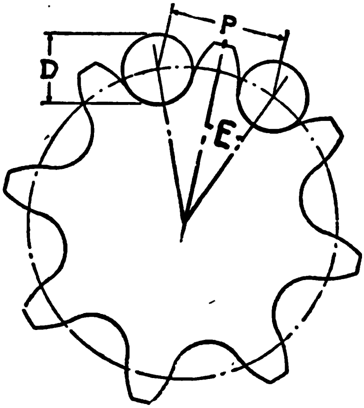
Distance A between centers should not be less than $1\frac{1}{2}$ times the diameter (2 R) of the larger sprocket nor more than 60 × P.

In using the above formula for calculating the length of block chains, the length should be a multiple of the pitch. For roller, the length is a multiple of two times the pitch, as the ends have to be joined by an inside and outside link.

A sprocket wheel should not have less than 15 teeth. On sprockets of the same diameter a short pitch chain will last longer and run more quietly than a long pitch.

As to tooth forms, the Diamond Chain & Manufacturing Co. has developed a tooth having a constant pressure angle and a variable space angle. A large pressure angle is one of the advantages claimed. Besides, an elongated chain will run as well on a 100 tooth sprocket as on a 20.

SPROCKET WHEELS



Diameters of Sprocket Wheels for Block Center and Twin Roller Chains

P = pitch of chain

N = number of teeth in sprocket

$$E = \frac{180^\circ}{N}$$

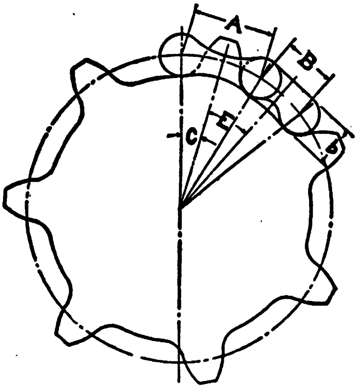
$$\text{Pitch dia.} = \frac{P}{\sin E}$$

D = diameter of roller

$$\text{Outside diameter of sprocket wheel} = \frac{P}{\sin E} + D$$

$$\text{Bottom `` `` `` ``} = \frac{P}{\sin E} - D$$

DIAMETERS OF SPROCKET WHEELS FOR ROLLER AND BUILT UP BLOCK CHAINS



A = center to center of holes in side links (usually .6)
B = " " " " " " chain block (usually .4)
b = diameter of round part of chain block (usually .325)
N = number of teeth

$$E = \frac{180^\circ}{N}$$

$$\text{Tan } C = \frac{\sin E}{\frac{B}{A} + \cos E}$$

$$\text{Pitch dia.} = \frac{A}{\sin C}$$

$$\text{Outside diameter of sprocket wheel} = \frac{A}{\sin c} + b$$

$$\text{Bottom " " " "} = \frac{A}{\sin c} - b$$

[Whitney Mfg. Co., Hartford, Conn.]

Formulae

Pitch dia. approx. of sprocket wheel = .318 × number of teeth × pitch ins.

$$\text{Chain pull in pounds} = \frac{33{,}000 \times \text{horse power}}{\text{vel. of chain ft. per min.}}$$

[Diamond Chain & Mfg. Co., Indianapolis.]

GEARING

SPUR GEARS

Circular pitch (P′) is the distance measured along the pitch circle from the center of one tooth to the center of the next. Circular pitch $= \frac{3.1416}{\text{diameter pitch.}}$

Diametral pitch (P) is the number of teeth to each inch of the pitch diameter. Diametral pitch $= \frac{3.1416}{\text{circular pitch.}}$

Addendum is the distance from the pitch circle to the outside diameter.

Dedendum is the distance from the pitch circle to the bottom of the working depth.

Clearance is the distance from the working depth to the bottom of the tooth.

P' = circular pitch.
P = diametral pitch.
D' = diameter of pitch circle.
D = outside diameter.
N = number of teeth.
a = addendum.
c = clearance.
t = thickness of tooth.

Then

$$P' = \frac{3.1416}{P} = \frac{D}{.3183N + 2} = \frac{D'}{.3183N}$$

$$P = \frac{3.1416}{P'}$$

$$D' = .3183\ N\ P' = \frac{N\ D}{N + 2} = N\ a$$

$$D = a\ (N + 2) = .6366\ P' + D'$$

$$a = .3183\ P'$$

$$c = .05\ P = \frac{t}{10}$$

$$t = \frac{P'}{2}$$

Usual width of face of spur gears is 2½ to 3 times the circular pitch.

Small pinions which run with large diameter gears should be shrouded as the shrouding gives additional strength to the pinion. The shrouding on each side may be taken equal to .4 circular pitch plus ⅛ in.

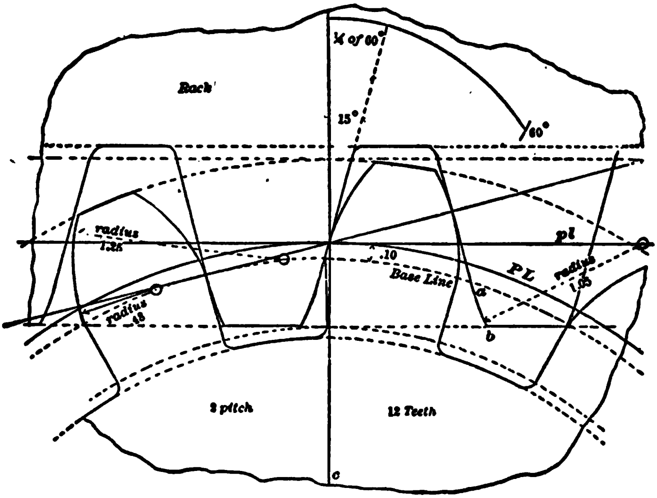
Tooth Forms.—Gear teeth may be constructed with involute, epicycloid or hypocycloid curves (see pages 20–22). The curve generally selected is the involute above the pitch line with radial flanks. The outlines of involute and epicycloidal teeth may be laid out by Grant's odontograph.

Involute gears to be interchangeable must have the same angle of obliquity. Gears with cycloidal tooth outlines to be interchangeable must have the same rolling circle on both flanks and faces.

The addendum line is drawn outside of the pitch line at a distance equal to one divided by the diametral pitch, or to one-third of the circular pitch. The dedendum line is inside of the pitch line by the same distance. The clearance line is inside of the dedendum line by one-eighth of this distance. The base line is inside of the pitch line by one-sixtieth of the pitch diameter.

To Draw a Gear.—Draw the pitch line, addendum, dedendum, clearance and base lines. Space the pitch line for the tooth points, either by dividing the full circle, or by stepping off half the circular pitch.

In the odontograph table at 12 teeth (the number of teeth in the gear to be drawn), is found the face radius 2.51 and this, divided by the diametral pitch 2, gives 1.25. With compass set to this face radius viz. 1.25 draw the faces of the teeth from the addendum



line to the pitch line, from centers on the base line. If the number of teeth is greater than 36, or if the pitch is small, this face radius should be continued to the base line.

At twelve teeth in the table is found the flank radius .96, and this divided by the diametral pitch gives a quotient of .48. With the compass set to .48, and from centers on the base line, draw in all the flanks of the teeth from the pitch line to the base line.

From the base line continue the flanks of the teeth to the dedendum line by straight radial lines, and round them into the clearance line, completing the teeth.

To Draw a Rack.—Draw straight lines at an angle of 15 degs. with the radius line. The point of the tooth, from the halfway point to the point b must be rounded over by an arc drawn from a center on the pitch line, and with the compasses set to 2.10 ins. divided by the diametral pitch, or .67 inch multiplied by the circular pitch.

Grant's Odontograph for Involute Teeth

Pressure angle = 15 degs. Addendum = .3183 × circular pitch = $\frac{1}{\text{diametral pitch}}$. Clearance = $\frac{\text{addendum}}{8}$

No. of teeth	Divide by the diametral pitch		Multiply by the circular pitch		Number of Teeth	Divide by the diametral pitch		Multiply by the circular pitch	
	Face rad.	Flank rad.	Face rad.	Flank rad.		Face rad.	Flank rad.	Face rad.	Flank rad.
10	2.28	.69	.73	.22	28	3.92	2.59	1.25	.82
11	2.40	.83	.76	.27	29	3.99	2.67	1.27	.85
12	2.51	.96	.80	.31	30	4.06	2.76	1.29	.88
13	2.62	1.09	.83	.34	31	4.13	2.85	1.31	.91
14	2.72	1.22	.87	.39	32	4.20	2.93	1.34	.93
15	2.82	1.34	.90	.43	33	4.27	3.01	1.36	.96
16	2.92	1.46	.93	.47	34	4.33	3.09	1.38	.99
17	3.02	1.58	.96	.50	35	4.39	3.16	1.39	1.01
18	3.12	1.69	.99	.54	36	4.45	3.23	1.41	1.03
19	3.22	1.79	1.03	.57	37–40	4.2	4.2	1.34	1.34
20	3.32	1.89	1.06	.60	41–45	4.63	4.63	1.48	1.48
21	3.41	1.98	1.09	.63	46–51	5.06	5.06	1.61	1.61
22	3.49	2.06	1.11	.66	52–60	5.74	5.74	1.83	1.83
23	3.57	2.15	1.13	.69	61–70	6.52	6.52	2.07	2.07
24	3.64	2.24	1.16	.71	71–90	7.72	7.72	2.46	2.46
25	3.71	2.33	1.18	.74	91–120	9.78	9.78	3.11	3.11
26	3.78	2.42	1.20	.77	121–180	13.38	13.38	4.26	4.26
27	3.85	2.50	1.23	.80	181–360	21.62	21.62	6.88	6.88

[Phila. Gear Works, Phila., Pa.]

Grant's Odontograph for Epicycloidal Teeth

$$\text{Addendum} = .3183 \times \text{circ. pitch} = \frac{1}{\text{dia'l pitch}}. \quad \text{Clearance} = \frac{\text{addendum}}{8}$$

Number of teeth		For one diametral pitch: for any other pitch, divide by that pitch				For one in. circular pitch, for any other pitch multiply by that pitch			
		Faces		Flanks		Faces		Flanks	
Exact	Intervals	Rad.	Distance	Rad.	Distance	Rad.	Distance	Rad.	Distance
10	10	1.99	.02	− 8.00	4.00	.62	.01	−2.55	1.27
11	11	2.00	.04	−11.05	6.50	.63	.01	−3.34	2.07
12	12	2.01	.06	Straight	Straight	.64	.02	Straight	Straight
13½	13–14	2.04	.07	15.10	9.43	.65	.02	4.80	3.00
15½	15–16	2.10	.09	7.86	3.46	.67	.03	2.50	1.10
17½	17–18	2.14	.11	6.13	2.20	.68	.04	1.95	.70
20	19–21	2.20	.13	5.12	1.57	.70	.04	1.63	.50
23	22–24	2.26	.15	4.50	1.13	.72	.05	1.43	.36
27	25–29	2.33	.16	4.10	.96	.74	.05	1.30	.29
33	30–36	2.40	.19	3.80	.72	.76	.06	1.20	.23
42	37–48	2.48	.22	3.52	.63	.79	.07	1.12	.20
58	49–72	2.60	.25	3.33	.54	.83	.08	1.06	.17
97	73–144	2.83	.28	3.14	.44	.90	.09	1.00	.14
290	145–300	2.92	.31	3.00	.38	.93	.10	.95	.12
Rack	Rack	2.96	.34	2.96	.34	.94	.11	.94	.11

[Phila. Gear Works, Phila., Pa.]

Stub Teeth

Stub teeth generally have a pressure angle of 20 degs., and the distance from the pitch diameter to the end of the tooth less than in ordinary teeth. For instance, for a 6 pitch tooth an 8 pitch addendum is used, as per following table which gives dimensions of stub teeth.

Diametral pitch	Thickness on pitch line	Addendum	Dedendum	Diametral pitch	Thickness on pitch line	Addendum	Dedendum
$^4/_5$	.3927	.2000	.2500	$^8/_{10}$	.1962	.1000	.1250
$^5/_7$	.3142	.1429	.1785	$^9/_{11}$	.1744	.0909	.1137
$^6/_8$	.2617	.1250	.1562	$^{10}/_{12}$	.1571	.0833	.1042
$^7/_9$	.2243	.1111	.1389	$^{12}/_{14}$	.1308	.0714	.0893

Circular Pitch

With its Equivalent in Diametral Pitch, Depth of Space and Thickness of Tooth

Circular Pitch	Diametral Pitch	Thickness of Tooth On Pitch Line	Depth to be Cut in Gear	Addendum
6	.5236	3.0000	4.1196	1.9098
5	.6283	2.5000	3.4330	1.5915
4	.7854	2.0000	2.7464	1.2732
3½	.8976	1.7500	2.4031	1.1140
3	1.0472	1.5000	2.0598	.9550
2¾	1.1424	1.3750	1.8882	.8754
2½	1.2566	1.2500	1.7165	.7958
2¼	1.3963	1.1250	1.5449	.7162
2	1.5708	1.0000	1.3732	.6366
1⅞	1.6755	.9375	1.2874	.5968
1¾	1.7952	.8750	1.2016	.5570
1⅝	1.9333	.8125	1.1158	.5173
1½	2.0944	.7500	1.0299	.4775
1⅜	2.2848	.6875	.9441	.4377
1¼	2.5133	.6250	.8583	.3979
1⅛	2.7925	.5625	.7724	.3581
1	3.1416	.5000	.6866	.3183
15/16	3.3510	.4687	.6437	.2984
⅞	3.5904	.4375	.6007	.2785
13/16	3.8666	.4062	.5579	.2586
¾	4.1888	.3750	.5150	.2387
11/16	4.5696	.3437	.4720	.2189
⅝	5.0265	.3125	.4291	.1989
9/16	5.5851	.2812	.3862	.1790
½	6.2832	.2500	.3433	.1592
7/16	7.1808	.2187	.3003	.1393
⅜	8.3776	.1875	.2575	.1194
5/16	10.0531	.1562	.2146	.0995
¼	12.5664	.1250	.1716	.0796
⅛	25.1327	.0625	.0858	.0398
1/16	50.2655	.0312	.0429	.0199

Diametral Pitch

With its Equivalent in Circular Pitch, Depth of Space and Thickness of Tooth

Diametral Pitch	Circular Pitch	Thickness of Tooth on Pitch Line	Depth to be Cut in Gear	Addendum
½	6.2832	3.1416	4.3142	2.0000
¾	4.1888	2.0944	2.8761	1.3333
1	3.1416	1.5708	2.1571	1.0000
1¼	2.5133	1.2566	1.7257	.8000
1½	2.0944	1.0472	1.4381	.6666
1¾	1.7952	.8976	1.2326	.5714
2	1.5708	.7854	1.0785	.5000
2¼	1.3963	.6981	.9587	.4444
2½	1.2566	.6283	.8628	.4000
2¾	1.1424	.5712	.7844	.3636
3	1.0472	.5236	.7190	.3333
3½	.8976	.4488	.6163	.2857
4	.7854	.3927	.5393	.2500
5	.6283	.3142	.4314	.2000
6	.5236	.2618	.3595	.1666
7	.4488	.2244	.3081	.1429
8	.3927	.1963	.2696	.1250
9	.3491	.1745	.2397	.1111
10	.3142	.1571	.2157	.1000
11	.2856	.1428	.1961	.0909
12	.2618	.1309	.1798	.0833
14	.2244	.1122	.1541	.0714
16	.1963	.0982	.1348	.0625
18	.1745	.0873	.1198	.0555
20	.1571	.0785	.1079	.0500
22	.1428	.0714	.0980	.0455
24	.1309	.0654	.0898	.0417
26	.1208	.0604	.0829	.0385
28	.1122	.0561	.0770	.0357
30	.1047	.0524	.0719	.0333
32	.0982	.0491	.0674	.0312
36	.0873	.0436	.0599	.0278
40	.0785	.0393	.0539	.0250
48	.0654	.0327	.0449	.0208

Horse Power and Working Loads of Cut Cast Iron Spur Gears

Under the heading W L is given the working load or number of pounds of power transmitting strain which can safely be brought on each inch width of tooth of a cut cast iron gear or pinion of the size indicated at left of table, when it is running at the speed listed at top. For horse power and working loads of cut cast steel spur gear multiply the figures in the table by 204.

Under the heading H. P. this is converted into Horse Power transmitted at the speed named.

These figures should be multiplied by the width of working face in inches, for the power of the gear in question.

The feet per minute at pitch line equals pitch diameter in inches multiplied by revolutions per minute and by .2618.

Speed of Pitch Line

Diametral Pitch	Arc Pitch	No. of Teeth	Feet per minute											
			100		200		300		600		900		1200	
			W.L	H.P.	W.L	H.P.	W.L	H.P.	W.L	H.P.	W.L	H.P.	W.L	H.P.
		12	90	.27	79	.47	70	.63	53	.96	42	1.15	35	1.27
		20	120	.36	105	.63	94	.85	70	1.27	56	1.53	47	1.71
10	.3142	40	145	.44	127	.76	113	1.02	85	1.55	68	1.86	56	2.04
		60	152	.46	133	.80	119	1.07	89	1.62	71	1.94	60	2.18
		130	160	.49	140	.84	124	1.12	94	1.71	74	2.02	62	2.26
		12	113	.34	98	.59	87	.78	66	1.20	52	1.42	44	1.60
		20	150	.45	130	.78	116	1.04	87	1.58	70	1.91	58	2.11
8	.392	40	180	.55	158	.95	141	1.27	105	1.91	84	2.29	70	2.54
		60	190	.58	165	.99	148	1.33	110	2.00	88	2.40	74	2.69
		130	200	.61	174	1.04	155	1.40	115	2.09	92	2.51	77	2.80
		12	225	.68	195	1.17	175	1.58	130	2.36	105	2.86	87	3.16
		20	300	.91	260	1.56	230	2.08	175	3.18	140	3.82	116	4.22
4	.785	40	360	1.09	315	1.89	280	2.52	210	3.82	170	4.64	140	5.09
		60	380	1.15	330	1.98	295	2.68	220	4.00	177	4.83	147	5.35
		130	400	1.21	350	2.10	310	2.79	230	4.18	185	5.05	155	5.64
		12	300	.91	260	1.56	232	2.08	175	3.18	140	3.82	116	4.22
		20	400	1.21	350	2.10	310	2.79	232	4.22	185	5.05	155	5.64
3	1.047	40	480	1.45	420	2.52	373	3.36	280	5.10	225	6.14	187	6.80
		60	503	1.52	440	2.64	391	3.52	295	5.37	235	6.42	196	7.13
		130	530	1.61	462	2.77	411	3.70	310	5.64	248	6.77	206	7.50

(*Continued on page 148.*)

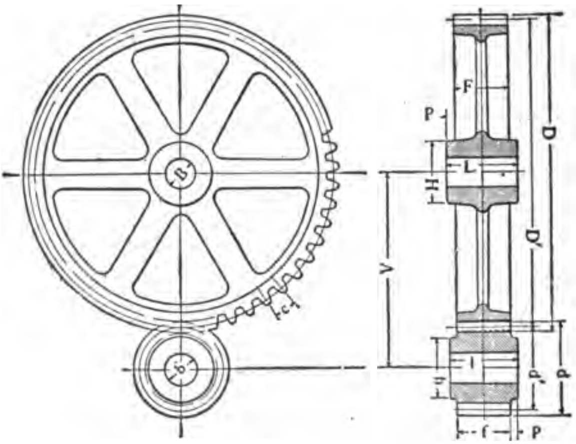
SPEED OF PITCH LINE—*Continued*

Diametral Pitch-	Arc. Pitch	No. of Teeth	Feet per minute											
			100		200		300		600		900		1200	
			W.L	H.P.	W.L	H.P.	W.L	H.P.	W.L	H.P.	W.L	H.P.	W.L	H.P.
2	1.57	12	450	1.37	390	2.34	350	3.15	260	4.73	209	5.71	174	6.33
		20	600	1.82	520	3.12	467	4.20	350	6.37	280	7.64	232	8.44
		40	720	2.18	630	3.78	560	5.04	420	7.64	348	9.50	280	10.20
		60	760	2.30	663	3.98	592	5.33	442	8.05	355	9.70	295	10.72
		130	795	2.40	695	4.17	619	5.57	462	8.40	370	10.10	309	11.23
1½	2.09	12	595	1.80	520	3.12	462	4.16	348	6.34	278	7.59	230	8.37
		20	800	2.42	700	4.20	620	5.58	466	8.47	372	10.15	310	11.28
		40	963	2.92	840	5.04	750	6.75	560	10.20	450	12.28	372	13.52
		60	1010	3.06	880	5.28	780	7.03	585	10.65	470	12.82	390	14.20
		130	1060	3.21	925	5.55	820	7.38	617	11.22	493	13.44	410	14.90

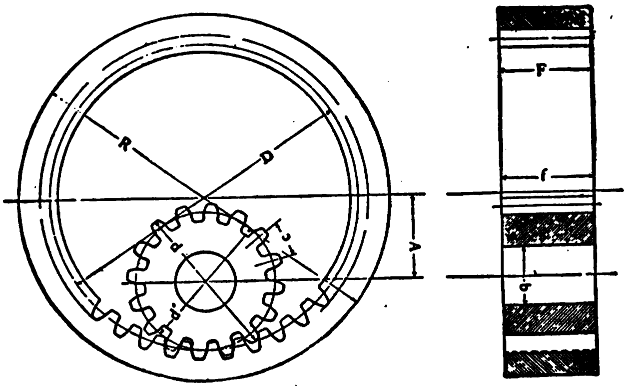
[Link Belt Co., Chicago, Ill.]

Forms for Ordering

SPUR GEAR AND PINION



INTERNAL GEAR AND PINION



Gear			Pinion		
Number of Teeth.....			Number of Teeth......		
Pitch... Circular	=	C	Pitch...... Circular	=	c
Pitch... Diametral	=		Pitch...... Diametral	=	
Face................	=	F	Face.................	=	f
Bore................	=	B	Bore.................	=	b
Pitch Diameter......	=	D′	Pitch Diameter........	=	d′
Outside Diameter....	=	D	Outside Diameter......	=	d
Diameter of Hub.....	=	H	Diameter of Hub.......	=	h
Length of Hub.......	=	L	Length of Hub.......	=	l
Projection of Hub....	=	P	Projection of Hub......	=	p
Keyway.............			Keyway..............		
Material............			Material..............		

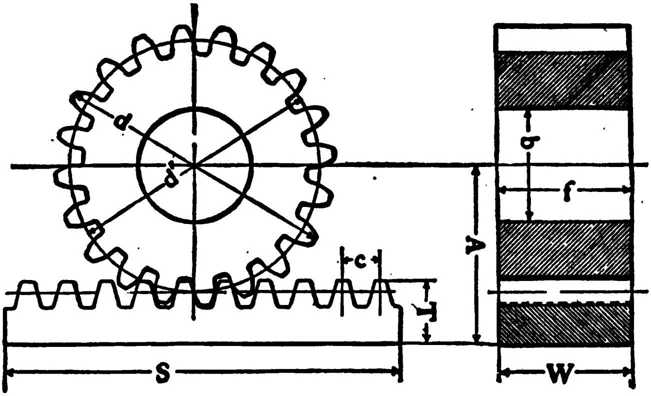
Distance between centers = A

Materials for Gears

Gears may be of cast iron, cast steel, bronze or rawhide. Cast iron gears can be obtained either with cast (molded) teeth or generated (cut). Cast teeth are for rough drives but for accuracy, cut teeth are preferable; in any case a peripheral speed of 1,100 ft. per min. must not be exceeded as the noise becomes excessive. For working

loads of cast iron gears, see page 147. Rawhide gears run quietly, but the pressure on the teeth should not exceed 240 lbs. per in. of face.

MACHINE RACK AND PINION



Rack

Pitch	Circular	=	C
	Diametral	=	3.1416÷C
Thickness		=	T
Face		=	W
Length of Rack		=	S
Material		=	
Center of Pinion to Bottom of Rack		=	A

Pinion

Number of Teeth		=	
Pitch	Circular	=	c
	Diametral	=	*
Pitch Diameter		=	d
Outside Diameter		=	d′
Bore		=	b
Face		=	f
Keyway		=	
Material		=	

* Number of teeth to inch of Pitch Diameter.

[Foote Bros. Gear & Machine Co., Chicago, Ill.]

MITER AND BEVEL

Miter gears have their axes meet at 90 degs., both gears being the same size. Bevel gears have their axes meet at other than 90 degs.

Center Angle.—Divide the number of teeth in the pinion by the number of teeth in the gear, the quotient is the tangent of the center angle of the pinion and cotangent of center angle of gear.

Increase Angle.—Divide double the sine of the center angle by the number of teeth in the pinion, the quotient is the tangent of increase angle for pinion or gear.

Face Angle.—Add the increase angle to the center angle of either gear, and the sum is the face angle.

Cut Angle.—Subtract the increase angle from the center angle of either gear, and the remainder is the cut angle.

Back Angle.—Subtract the increase angle from 90 degrees and the r mainder is the back angle for either gear.

Diameter Increase.—Double the cosine of the center angle and divide it by the diametral pitch, the quotient is the diameter increase, which added to the pitch diameter, is the outside diameter. The diameter increase is not the same for pinion and gear. They are calculated separate from center angles as above.

To Find the Length of Face on a Pair of Bevel Gears.—Multiply the secant of center angle of pinion by the radius of gear, and take one-third of product. Example: A gear is 6 ins. dia., and pinion 3 ins., find the face of the gear.

$$\frac{3''}{6''} = .5000 = \text{tangent of angle.}$$

Secant of angle $= 1.1174 \times 3''$ (radius gear) $= 3.352$.

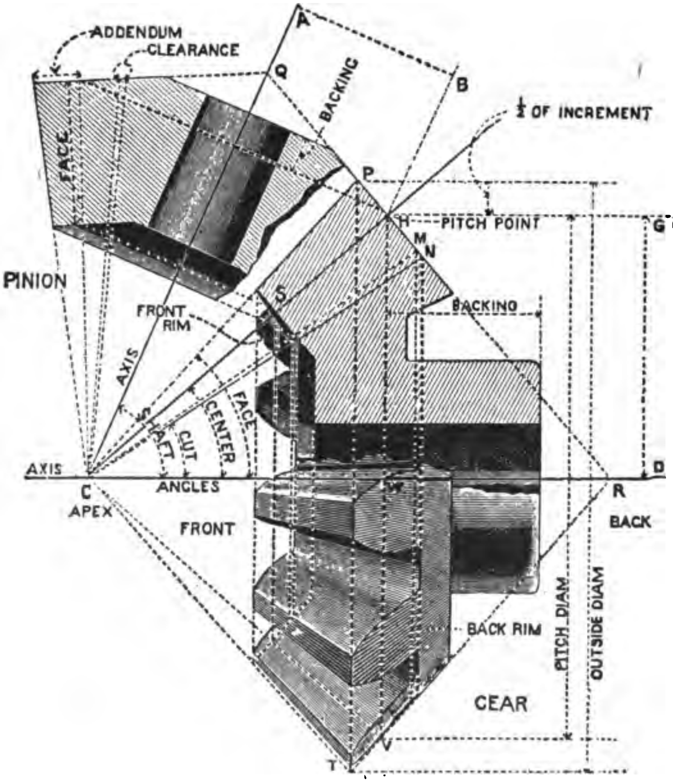
$$\text{Face of gear} = \frac{3.352}{3} = 1.11''.$$

In bevel gears, to find the thickness of tooth at small end, divide the distance from apex to small end of tooth by the distance from apex to pitch diameter, and the quotient is the ratio. Multiply the thickness of tooth at pitch line by the ratio just found, and the product is the thickness of tooth at the pitch line of small end of tooth.

To find the pitch line at the small end of the tooth, multiply the ratio as obtained above by the addendum, the product is the addendum at the small end of the tooth.

[Foote Bros., Gear & Mach. Co., Chicago, Ill.]

To Draw a Pair of Bevel Gears at any Shaft Angle. (See page 152.) —Draw the given axes A C and D C meeting at the apex C. Lay off the distances A B and D G equal to the pitch radii of the gears. Draw B H and G H parallel to the axes, and from their intersection, the pitch point H, draw the center line H C to the apex. Lay off H S equal to the given face. Draw Q H R at right angles to H C.



Lay off H P and H M each equal to the known addendum and M N equal to the known clearance. Draw P C, M C and N C.

P C H is the increment angle or the addendum angle. P C D is the face angle, N C D is the cut angle.

The "backing" is the distance from the pitch line to the back end of the hub.

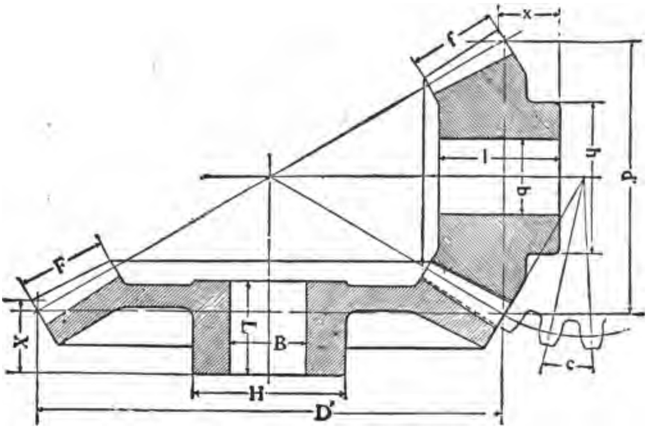
The small ends of the teeth are at the "front," and the large ends at the "back" of the gear.

The working pitch diameter of the gear is the diameter H V. The outside diameter is P T. The increment or difference between

the pitch and the outside diameters, is variable with the angle of the gear, not being the same for all gears of the same pitch, as with spur gears.

[Phila. Gear Works, Phila., Pa.]

Form for Ordering

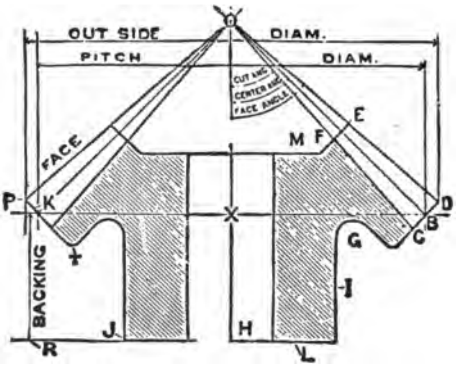


Gear			Pinion		
Number of Teeth.....	=		Number of Teeth.....	=	
Pitch...... Circular..	=	C	Pitch...... Circular..	=	c
Pitch...... Diametral	=	*	Pitch...... Diametral	=	*
Face................	=	F	Face................	=	f
Bore................	=	B	Bore................	=	b
Pitch Diameter.......	=	D′	Pitch Diameter.......	=	d′
Backing.............	=	X	Backing.............	=	x
Length Through Hub.	=	L	Length Through Hub.	=	l
Diameter of Hub.....	=	H	Diameter of Hub.....	=	h
Keyway.............	=		Keyway.............	=	
Material............	=		Material............	=	

When ordering either gear or pinion, always give number of teeth of mate. Distance x is sometimes taken to the pitch diameter—always state how it is taken.

* Number of teeth to inch of pitch diameter.

Mitre Gear Angles and Outside Diameter of One Diametral Pitch



NOTE—To obtain outside diameter, divide diameter given in table by the required diametral pitch. Angles given are fixed for the number of teeth as listed.

Number of teeth	Face Angle	Back Angle	O.D. for one Dia. Pitch	Number of teeth	Face Angle	Back Angle	O.D. for one Dia. Pitch
8	55.12	10.12	9.41	76	46.06	1.06	77.41
9	54.00	9.00	10.41	77	46.05	1.05	78.40
10	53.10	8.10	11.41	78	46.03	1.03	79.41
11	52.36	7.36	12.41	79	46.02	1.02	80.41
12	51.75	6.75	13.41	80	46.00	1.00	81.41
13	51.23	6.23	14.41	81	46.00	1.00	82.41
14	50.79	5.79	15.41	82	45.98	.98	83.41
15	50.40	5.40	16.41	83	45.97	.97	84.41
16	50.06	5.06	17.41	84	45.96	.96	85.41
17	49.80	4.80	18.41	85	45.95	.95	86.41
18	49.50	4.50	19.41	86	45.94	.94	87.41
19	49.30	4.30	20.41	87	45.93	.93	88.41
20	49.05	4.05	21.41	88	45.92	.92	89.41
21	48.86	3.86	22.41	89	45.91	.91	90.41
22	48.68	3.68	23.41	90	45.90	.90	91.41
23	48.52	3.52	24.41	91	45.89	.89	92.41
24	48.37	3.37	25.41	92	45.88	.88	93.41
25	48.24	3.24	26.41	93	45.88	.88	94.41
26	48.11	3.11	27.41	94	45.87	.87	95.41
27	48.00	3.00	28.41	95	45.87	.86	96.41
28	47.89	2.89	29.41	96	45.86	.85	97.41
29	47.79	2.79	30.41	97	45.86	.84	98.41
30	47.67	2.67	31.41	98	45.85	.83	99.41

Number of teeth	Face Angle	Back Angle	O.D. for one Dia. Pitch	Number of teeth	Face Angle	Back Angle	O.D. for one Dia. Pitch
31	47.61	2.61	32.41	99	45.85	.83	100.41
32	47.53	2.53	33.41	100	45.84	.82	101.41
33	47.45	2.45	34.41	102	45.79	.79	103.41
34	47.39	2.39	35.41	104	45.78	.78	105.41
35	47.31	2.31	36.41	105	45.77	.77	106.41
36	47.24	2.24	37.41	106	45.76	.76	107.41
37	47.19	2.19	38.41	108	45.75	.75	109.41
38	47.13	2.13	39.41	110	45.73	.73	111.41
39	47.08	2.08	40.41	112	45.72	.72	113.41
40	47.00	2.00	41.41	114	45.71	.71	115.41
41	46.97	1.97	42.41	116	45.70	.70	117.41
42	46.93	1.93	43.41	118	45.69	.69	119.41
43	46.88	1.88	44.41	120	45.68	.68	121.41
44	46.84	1.84	45.41	122	45.66	.66	123.41
45	46.80	1.80	46.41	124	45.65	.65	125.41
46	46.76	1.76	47.41	126	45.64	.64	127.41
47	46.72	1.72	48.41	128	45.63	.63	129.41
48	46.68	1.68	49.41	130	45.62	.62	131.41
49	46.65	1.65	50.41	132	45.61	.61	133.41
50	46.62	1.62	51.41	134	45.60	.60	135.41
51	46.58	1.58	52.41	136	45.59	.59	137.41
52	46.55	1.55	53.41	138	45.58	.58	139.41
53	46.52	1.52	54.41	140	45.57	.57	141.41
54	46.50	1.50	55.41	142	45.56	.56	143.41
55	46.47	1.49	56.41	144	45.55	.55	145.41
56	46.44	1.44	57.41	146	45.55	.55	147.41
57	46.41	1.41	58.41	148	45.55	.55	149.41
58	46.38	1.38	59.41	150	45.54	.54	151.41
59	46.35	1.35	60.41	152	45.54	.54	153.41
60	46.33	1.34	61.41	154	45.53	.53	155.41
61	46.32	1.32	62.41	156	45.52	.52	157.41
62	46.30	1.30	63.41	158	45.51	.51	159.41
63	46.28	1.28	64.41	160	45.50	.50	161.41
64	46.26	1.26	65.41	..	..	..	.....
65	46.24	1.24	66.41	..	..	..	.....
66	46.22	1.22	67.41	..	..	..	.....
67	46.20	1.20	68.41	..	..	..	.....
68	46.19	1.19	69.41	..	..	..	.....
69	46.18	1.18	70.41	..	..	..	.....
70	46.16	1.16	71.41	..	..	..	.....
71	46.15	1.15	72.41	..	..	..	.....
72	46.11	1.11	73.41	..	..	..	.....
73	46.09	1.09	74.41	..	..	..	.....
74	46.08	1.08	75.41	..	..	..	.....
75	46.06	1.06	76.41	..	..	..	.....

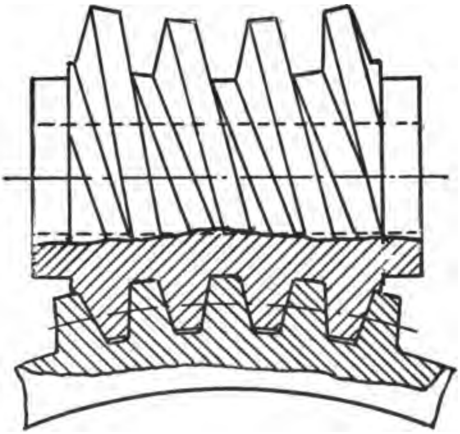
Worm Gearing

Terms—pitch and diametral pitch are same as for spur gears. Lead = number of threads × linear pitch. Linear pitch of worm = circular pitch of wheel. Normal pitch = cosine of lead angle × linear pitch. Pitch dia. of wheel = $\frac{\text{number of teeth} \times \text{cir. pitch.}}{\pi}$

Cotangent of lead angle = $\frac{\text{pitch dia. of worm} \times \pi}{\text{lead}}$. In gear table on pages 158 and 159, axial tooth angle = 60 degs., pressure angle = 30 degs.

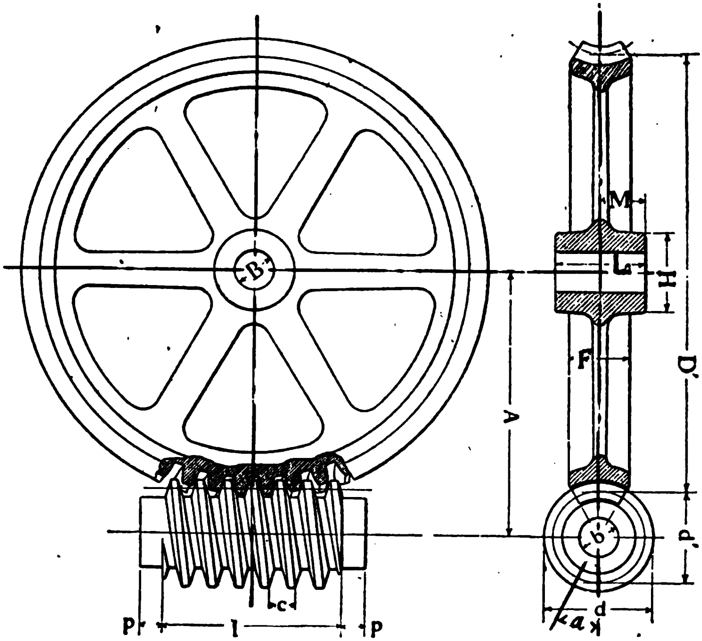
Worm wheels have straight or concave faces, an illustration of the latter is shown on page 157. Angle A is preferably 30 degs., although it may be between 30 and 35. Wheels may have the following proportions in terms of circular pitch P. Width of face = 2 P. Dimensions of tooth on pitch line, thickness = .49 P, height = .35 P, depth = .45 P.

Curved Worm



Worms are either straight or curved. The straight has a constant pitch diameter over its entire surface. In the curved, the worm has the form of an hour glass, the object being to get a greater surface contact than can be obtained with a straight worm. The Hindley worm is of the curved type. To get the maximum efficiency the worm should be as small in diameter as practical. Length generally six times the pitch.

Form for Ordering Worm and Worm Gear



Worm Gear			Worm		
Number of Teeth......	=		Pitch..................	=	c
Pitch (Circular).......	=	C	(Distance from center to center of teeth.)		
Face.................	=	F	Lead (Advance in one revolution)		
Bore.................	=	B			
Pitch Diameter.......	=	D'	Pitch Diameter........	=	d'
Length Through Hub..	=	L	Outside Diameter......	=	d
Projection from Center	=	M	Bore.................	=	b
Keyway.............			Length...............	=	l
Material............			Projection of Hub......	=	p
Right or Left Hand....			Keyway..............		
			Material.............		
			Right or Left Hand....		

Distance between Centers............ = A

Worms and Gears

Centers	Ratio	Reduction	Normal Pitch	Lineal Pitch	Pitch Dia. of Worm	Lead Angle	Lead	Ctr's. Change Per Wheel Tooth	Hand	Used For	H. P. at 1000 R. P. M.
2.120	11-10	.909	.448	.6335	2.222	45°		.1008	R. H.	Engine Timing Gears	
2.2165	4-21	5.25	.4286	.47656	1.2474	25°-56′	1.90625	.0758	R. H.	Refrigerating Mach.	½
2.650	3-51	17	.2445	.2455	1.2496	10°-49′	.750	.039	L. H.	Self Starter	
2.800	11-30	2 8-11	.314	.373	2.0202	32°-44′		.0593	L. H.	Engine Timing Gears	
2.8125	6-46	7.66	.2724	.308	1.115	27°-48′	1.848	.049	R. H.	Refrigerating Mach.	⅙
2.8125	6-41	6.833	.298	.345	1.123	30°-23′	2.070	.0549	R. H.	Refrigerating Mach.	⅙
2.8125	6-38	6.33	.314	.372	1.125	32°-16′	2.232	.0592	R. H.	Refrigerating Mach.	⅙
2.8125	5-29	5.8	.403	.483	1.167	33°-22′	2.415	.0769	R. H.	Refrigerating Mach.	⅙
2.875	4-22	5.5	.481	.500	2.2486	15°-48′	2.000	.0796	R. H.	Steering	
3.440	11-15	1 4-11	.523	.9878	2.160	58°-2′		.1572	R. H.	Engine Timing Gears	
3.495	4-23	5.75	.6326	.750	1.500	32°-29′	3.000	.1193	R. H.	Small Tractor	
4.375	2-25	12.5	.712	.720	3.021	8°-37′	1.44	.1145	L. H.	Steering	
4.625	8-29	3.625	.542	.7985	1.8791	47°-15′	6.388	.1271	R. H.	Small Pleasure Car	
4.700	5-31	6.2	.6439	.74993	2.000	30°-49′	3.7496	.1193	R. H.	½ Ton Truck	15
4.700	4-28	7	.734	.83028	2.000	27°-51′	3.3211	.1321	R. H.	½ Ton Truck	15
4.700	6-27	4½	.665	.86103	2.000	39°-26′	5.166	.1370	R. H.	½ Ton Truck	15
4.700	5-21	4.2	.8306	1.10704	2.000	41°-22′	5.5353	.1762	R. H.	½ Ton Truck	15
4.700	3-31	10.33	.714	.77526	1.750	22°-55′	2.3258	.1234	R. H.	½ Ton Truck	15
4.700	3-44	14.66	.5234	.54621	1.750	16°-35′	1.6386	.0869	R. H.	Industrial Truck	15
4.934	2-33	16.5	.7293	.750	1.990	13°-29′	1.500	.1193	R. H.	Industrial Truck	
5.500	3-35	11.66	.7558	.83476	1.700	25°-7′	2.5043	.13285	R. H.	Industrial Truck	
5.500	7-27	3.857	.74192	.98902	2.500	41°-23′	6.923	.1574	R. H.	Med. Size Touring	30
5.500	3-44	14.66	.6227	.6783	1.500	23°-21′	2.0349	.10796	L. H.	Industrial Truck	
5.500	5-44	8.8	.5517	.6772	1.5143	35°-26′	3.38635	.10778	L. H.	Elec. Pleasure Car	6
5.500	6-29	4.833	.7385	.9479	2.250	38°-49′	5.6874	.1509	L. H.	Med. Size Touring	30
5.500	4-43	10.75	.60264	.6867	1.600	28°-39′	2.747	.1093	L. H.	Elec. Pleasure Car	6
5.511	5-43	8.6	.55385	.7000	1.4415	37°-42′	3.500	.1112	R. H.	Elec. Pleasure Car	6
5.511	2-35	17.5	.7954	.830	1.775	16°-34′	1.660	.1321	R. H.	Industrial Truck	
5.597	2-35	17.5	.8162	.870	1.501	20°-15′	1.740	.1389	R. H.	Industrial Truck	
5.696	4-33	8.25	.778	.890	2.043	29°-1′	3.560	.1416	R. H.	Utility Tractor	
5.875	2-35	17.5	.843	.875	2.002	15°-33′	1.750	.1393	R. H.	Industrial Truck	
5.975	4-29	7.25	.898	1.0625	2.142	32°-16′	4.250	.1691	R. H.	1 Ton Truck	22
5.975	4-29	7.25	.9034	1.050	2.2575	30°-38′	4.200	.1671	R. H.	1 Ton Truck	22

5.975	6-31	5.16	.7535	.984375	2.2366	40°-3′	5.90625	.1567	R. H.	1 Ton Truck	22
5.975	5-31	6.2	.80798	.9815	2.265	34°-35′	4.9075	.1562	R. H.	1 Ton Truck	22
5.975	5-36	7.2	.72496	.850	2.210	31°-28′	4.250	.1355	R. H.	1 Ton Truck	22
6.000	4-31	7.75	.8642	.960	2.527	25°-48′	3.840	.1528	R. H.	1 Ton Truck	22
6.548	4-26	6.5	1.082	1.250	2.751	30°-3′	5.000	.1989	R. H.	Motor Bus	
6.622	5-28	5.6	.96802	1.1875	2.660	35°-23′	5.9375	.189	R. H.	1½ Ton Truck	30
6.622	5-26	5.2	1.0242	1.2643	2.780	35°-54′	6.32185	.2012	R. H.	1½ Ton Truck	30
6.622	4-25	6.25	1.12698	1.3124	2.800	30°-49′	5.24972	.2089	R. H.	1½ Ton Truck	30
6.625	4-33	8.25	.90753	1.0234	2.500	27°-32′	4.0936	.1629	R. H.	1½ Ton Truck	
6.880	5-39	7.8	.7879	.89696	2.625	28°-32′	4.4848	.1427	R. H.	1½ Ton Truck	25
6.880	6-39	6.5	.75105	.89706	2.6238	33°-9′	5.3823	.1428	R. H.	1½ Ton Truck	25
7.125	4-25	6.25	1.215	1.375	3.308	27°-53′	5.500	.2189	R. H.	Motor Bus	50
7.343	4-29	7.25	1.10801	1.2968	2.715	31°-18′	5.1873	.2064	R. H.	2 Ton Truck	30
7.490	3-32	10.66	1.104	1.250	2.248	27°-58′	3.750	.1989	R. H.	2 Ton Truck	30
7.490	3-26	8.66	1.3155	1.4579	2.9135	25°-32′	4.3738	.2320	R. H.	2 Ton Truck	30
7.490	4-31	7.75	1.0774	1.1875	3.2622	24°-52′	4.750	.189	R. H.	2 Ton Truck	30
7.490	4-26	6.5	1.236	1.4375	3.084	30°-41′	5.750	.2288	R. H.	2 Ton Truck	37
7.490	3-29	9.66	1.192	1.275	3.211	20°-45′	3.825	.2029	R. H.	2 Ton Truck	29
7.490	3-44	14.66	.84629	.900	2.375	19°-53′	2.700	.1432	R. H.	2 Ton Elec. Truck	
7.721	3-27	9	1.31498	1.4687	2.819	26°-27′	4.406	.2337	R. H.	3 Ton Truck	36
7.721	3-30	10	1.2059	1.3437	2.610	26°-10′	4.03131	.2139	R. H.	3 Ton Truck	36
7.721	4-29	7.25	1.1632	1.368	2.8141	31°-45′	5.472	.2177	R. H.	3 Ton Truck	36
8.050	2-35	17.5	1.1556	1.200	2.731	15°-37′	2.400	.1910	R. H.	Tractor	
8.250	4-35	8.75	1.0776	1.21176	3.000	27°-13′	4.847	.1928	R. H.	2 Ton Truck	35
8.250	4-31	7.75	1.1831	1.3681	3.000	30°-8′	5.4725	.2177	R. H.	2 Ton Truck	40
8.250	3-53	17.66	.79113	.830	2.498	17°-36′	2.490	.1321	R. H.	2 Ton Truck	40
8.625	3-31	10.33	1.312	1.444	3.000	24°-41′	4.332	.2298	L. H.	Tractor	
8.815	3-34	11.33	1.241	1.375	2.749	25°-31′	4.125	.2189	R. H.	4 Ton Truck	33
9.050	4-47	11.75	.925	1.03125	2.6719	26°-10′	4.125	.1641	R. H.	3 and 5 Ton Truck	39
9.050	4-35	8.75	1.1636	1.375	2.7813	32°-11′	5.500	.2189	R. H.	3 and 5 Ton Truck	52
9.050	5-34	6.8	1.0997	1.41557	2.780	39°-1′	7.0778	.2253	L. H.	3 and 5 Ton Truck	
										2547	52
9.05	3-31	10.33	1.3758	1.53125	2.993	26°-2′	4.59375	.2437	R. H.	3 and 5 Ton Truck	52
9.295	3-32	10.66	1.3758	1.53125	2.993	26°-2′	4.59375	.2437	R. H.	5 and 6 Ton Truck	45
9.690	3-38	12.66	1.241	1.375	2.749	25°-31′	4.125	.2189	R. H.	5 Ton Truck	38
9.690	3-47	15.66	1.037	1.113	2.729	21°-16′	3.339	.1771	R. H.	7 Ton Truck	38
9.750	4-37	9.25	1.215	1.375	3.308	27°-53′	5.500	.2189	R. H.	5 and 6 Ton Truck	
13.250	3-43	14.33	1.52676	1.625	4.258	20°-1′-25	4.875	.2586	R. H.	Heavy Tractor	100

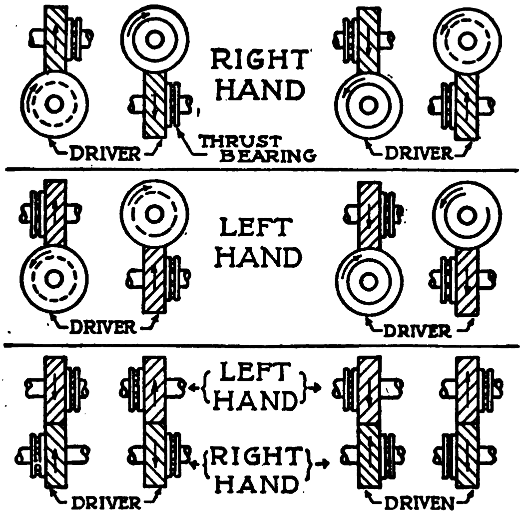
[Baush Machine Tool Co., Springfield, Mass.]

Helical Gears

Helical gears (often miscalled spiral gears) have angular teeth, and can be used when the shafts to be connected are not parallel.

The tooth dimensions are obtained from the normal pitch (determined by the cutter used) which is the same as the circular pitch of spur gears. The circumferential pitch depends on the tooth angle, and when this is 45 degs., the velocity at the pitch line is the same for both gears, but at angles other than 45 the velocity is different. With helical gears the velocity ratio depends on the tooth angles and the diameters of the pitch surfaces.

Direction of Rotation and Thrust of Helical Gears



[Boston Gear Works, Norfolk Downs, Mass.]

The driving gear is the one having the greatest tooth angle, the velocity being independent of the pitch diameters. Gears of the same hand will run together on shafts set at 90 degs., and those of opposite hand on parallel shafts. Helical gears are preferable to bevel when smooth running is required—furthermore greater speed reductions can be obtained with helical.

Formulæ

Driver	Follower
Pitch dia. $= \dfrac{\text{number of teeth} \times \text{cir. pitch}}{\pi}$	Pitch dia. $= \dfrac{\text{number of teeth} \times \text{cir. pitch}}{\pi}$
Circular pitch $= \dfrac{\pi \times \text{pitch dia.}}{\text{number of teeth}}$	Circular pitch $= \dfrac{\pi \times \text{pitch dia.}}{\text{number of teeth}}$
Cosine tooth pitch angle of driver $= \dfrac{\text{normal circular pitch}}{\text{circular pitch}}$	Tooth angle of follower = angle between shafts — tooth angle of driver

When the axes of the gears are at right angles, the number of teeth either in the driver or the follower = pitch dia. × normal pitch × cosine of tooth angle.

Herringbone Gears

Herringbone or double helical gears consist of two single helical gears reversed, that is, one right hand helix and one left hand. The teeth may meet at the center of the gear face, or the teeth may be staggered one half pitch apart as in the Wuest gear with a groove cut of one half the pitch on each side of the center of the gear face. In Wuest gears the teeth have a pitch angle of 23 degs., and are of involute form with a 20 deg. angle of obliquity.

P' = circular pitch

P = diametral pitch

N = number of teeth in a gear

W = width of face

Pitch dia. (20 teeth and over) $= \dfrac{N}{P}$

Pitch dia. (under 20 teeth) $= \dfrac{.95\,N + 1}{P}$

Addendum $= \dfrac{.8}{P}$

Dedendum $= \dfrac{1}{P}$

Full depth $= \dfrac{1.8}{P}$

Working depth $= \dfrac{1.6}{P}$

Standard face width for gears with pinions of not less than 25 teeth is equal to 6 P′, and for face widths for high ratio gears with small pinions 6 P′ to 12 P′.

SECTION IV

PIPE, TUBES AND FITTINGS

TRADE CUSTOMS—STANDARD WROUGHT IRON PIPE—EXTRA STRONG WROUGHT IRON PIPE—DOUBLE EXTRA STRONG WROUGHT IRON PIPE — COUPLINGS — NIPPLES — BOILER TUBES — STEEL TUBES — BRASS AND COPPER TUBES — PIPE BENDS —FLANGES—FITTINGS—VALVES—COCKS— EXPANSION JOINTS

Trade Customs Pertaining to Wrought Iron and Steel Pipe for Steam, Water and Gas.

Specify whether wrought iron or steel pipe is required.

Pipe is designated by its nominal inside diameter from 1/8 to 15 ins.; above 15 ins. by the outside diameter, the thickness being specified.

The outside diameter of pipe heavier than standard has the same diameter as standard, the extra thickness being on the inside.

The inside diameter of casings is always given.

The sizes of boiler tubes are indicated by their outside diameter.

Pipe is shipped in random lengths 18 to 21 ft. with threads and couplings, except extra and double extra strong which are shipped with plain ends. There is an extra charge for pipe cut to specified lengths—couplings not being furnished unless specified—pipe so cut is always measured to include the couplings.

Standard pipe cut to given lengths is always furnished with threaded ends. Extra strong and double extra strong have plain ends.

Pipe is furnished either butt or lap welded. Butt welded pipe may be obtained up to 3 ins. diameter, and lap welded from 1¼ in. up.

Pipe threads—see chapter on Threads.

In cutting pipe to order all dimensions should be given from center to center of valves and fittings.

Standard Wrought Iron and Steel Pipe

Size	Diameter		Nominal Thickness	Circumference		Transverse Areas			Length of Pipe per Square Foot of		Length of Pipe Containing One Cubic Foot	Nominal Weight per Foot		Number of Threads per Inch of Screw
	External	Approximate Internal		External	Internal	External	Internal	Metal	External Surface	Internal Surface		Plain Ends	Threaded and Coupled	
Inches	Inches	Inches	Inches	Inches	Inches	Sq. Ins.	Sq. Ins.	Sq. Ins.	Feet	Feet	Feet			
1/8	.405	.269	.068	1.272	.845	.129	.057	.072	9.431	14.199	2533.775	.244	.245	27
1/4	.540	.364	.088	1.696	1.144	.229	.104	.125	7.073	10.493	1383.789	.424	.425	18
3/8	.675	.493	.091	2.121	1.549	.358	.191	.167	5.658	7.747	754.360	.567	.568	18
1/2	.840	.622	.109	2.639	1.954	.554	.304	.250	4.547	6.141	473.906	.850	.852	14
3/4	1.050	.824	.113	3.299	2.589	.866	.533	.333	3.637	4.635	270.034	1.130	1.134	14
1	1.315	1.049	.133	4.131	3.296	1.358	.864	.494	2.904	3.641	166.618	1.678	1.684	11½
1¼	1.660	1.380	.140	5.215	4.335	2.164	1.495	.669	2.301	2.767	96.275	2.272	2.281	11½
1½	1.900	1.610	.145	5.969	5.058	2.835	2.036	.799	2.010	2.372	70.733	2.717	2.731	11½
2	2.375	2.067	.154	7.461	6.494	4.430	3.355	1.075	1.608	1.847	42.913	3.652	3.678	11½
2½	2.875	2.469	.203	9.032	7.577	6.492	4.788	1.704	1.328	1.547	30.077	5.793	5.819	8
3	3.500	3.068	.216	10.996	9.638	9.621	7.393	2.228	1.091	1.245	19.479	7.575	7.616	8
3½	4.000	3.548	.226	12.566	11.146	12.566	9.886	2.680	.954	1.076	14.565	9.109	9.202	8
4	4.500	4.026	.237	14.137	12.648	15.904	12.730	3.074	.848	.948	11.312	10.790	10.889	8
4½	5.000	4.506	.247	15.708	14.156	19.635	15.947	3.688	.763	.847	9.030	12.538	12.642	8
5	5.563	5.047	.258	17.477	15.856	24.306	20.006	4.300	.686	.756	7.198	14.617	14.810	8
6	6.625	6.065	.280	20.813	19.054	34.472	28.891	5.581	.576	.629	4.984	18.974	19.185	8
7	7.625	7.023	.301	23.955	22.063	45.664	38.738	6.926	.500	.543	3.717	23.544	23.769	8
8	8.625	8.071	.277	27.096	25.356	58.426	51.161	7.265	.442	.473	2.815	24.696	25.000	8
8	8.625	7.981	.322	27.096	25.073	58.426	50.027	8.399	.442	.478	2.878	28.554	28.809	8
9	9.625	8.941	.342	30.238	28.089	72.760	62.786	9.974	.396	.427	2.294	33.907	34.188	8
10	10.750	10.192	.279	33.772	32.019	90.763	81.585	9.178	.355	.374	1.765	31.201	32.000	8
10	10.750	10.136	.307	33.772	31.843	90.763	80.691	10.072	.355	.376	1.785	34.240	35.000	8
10	10.750	10.020	.365	33.772	31.479	90.763	78.855	11.908	.355	.381	1.826	40.483	41.132	8
11	11.750	11.000	.375	36.914	34.558	108.434	95.033	13.401	.325	.347	1.515	45.557	46.247	8
12	12.750	12.090	.330	40.055	37.982	127.676	114.800	12.876	.299	.315	1.254	43.773	45.000	8
12	12.750	12.000	.375	40.055	37.699	127.676	113.097	14.579	.299	.318	1.273	49.562	50.706	8

EXTRA STRONG WROUGHT IRON AND STEEL PIPE

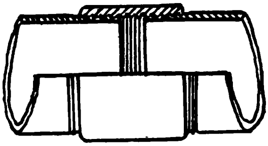
Diameter				Circumference		Transverse Areas			Length of Pipe per Square Foot of			
Nominal Internal	External	Approximate Internal Diameter	Nominal Thickness	External	Internal	External	Internal	Metal	External Surface	Internal Surface	Length of Pipe Containing One Cubic Foot	Nominal Weight per Foot Plain Ends
Inches	Inches	Inches	Inches	Inches	Inches	Sq. Inches	Sq. Inches	Sq. Inches	Feet	Feet	Feet	Pounds
1/8	.405	.215	.095	1.272	.675	.129	.036	.093	9.431	17.766	3966.392	.314
1/4	.540	.302	.119	1.696	.949	.229	.072	.157	7.073	12.648	2010.290	.535
3/8	.675	.423	.126	2.121	1.329	.358	.141	.217	5.658	9.030	1024.689	.738
1/2	.840	.546	.147	2.639	1.715	.554	.234	.320	4.547	6.995	615.017	1.087
3/4	1.050	.742	.154	3.299	2.331	.866	.433	.433	3.637	5.147	333.016	1.473
1	1.315	.957	.179	4.131	3.007	1.358	.719	.639	2.904	3.991	200.193	2.171
1¼	1.660	1.278	.191	5.215	4.015	2.164	1.283	.881	2.301	2.988	112.256	2.996
1½	1.900	1.500	.200	5.969	4.712	2.835	1.767	1.068	2.010	2.546	81.487	3.631
2	2.375	1.939	.218	7.461	6.092	4.430	2.953	1.477	1.608	1.969	48.766	5.022
2½	2.875	2.323	.276	9.032	7.298	6.492	4.238	2.254	1.328	1.644	33.976	7.661
3	3.500	2.900	.300	10.996	9.111	9.621	6.605	3.016	1.091	1.317	21.801	10.252
3½	4.000	3.364	.318	12.566	10.568	12.566	8.888	3.678	.954	1.135	16.202	12.505
4	4.500	3.826	.337	14.137	12.020	15.904	11.497	4.407	.848	.998	12.525	14.983
4½	5.000	4.290	.355	15.708	13.477	19.635	14.455	5.180	.763	.890	9.962	17.611
5	5.563	4.813	.375	17.477	15.120	24.306	18.194	6.112	.686	.793	7.915	20.778
6	6.625	5.761	.432	20.813	18.099	34.472	26.067	8.405	.576	.663	5.524	28.573
7	7.625	6.625	.500	23.955	20.813	45.664	34.472	11.192	.500	.576	4.177	38.048
8	8.625	7.625	.500	27.096	23.955	58.426	45.663	12.763	.442	.500	3.154	43.388
9	9.625	8.625	.500	30.238	27.096	72.760	58.426	14.334	.396	.442	2.464	48.728
10	10.750	9.750	.500	33.772	30.631	90.763	74.662	16.101	.355	.391	1.929	54.735
11	11.750	10.750	.500	36.914	33.772	108.434	90.763	17.671	.325	.355	1.587	60.075
12	12.750	11.750	.500	40.055	36.914	127.676	108.434	19.242	.299	.325	1.328	65.415

Double Extra Strong Wrought Iron and Steel Pipe

Diameter				Circumference		Transverse Areas			Length of Pipe per Square Foot of			
Nominal Internal	External	Approximate Internal Diameter	Nominal Thickness	External	Internal	External	Internal	Metal	External Surface	Internal Surface	Length of Pipe Containing One Cubic Foot	Nominal Weight per Foot Plain Ends
Inches	Inches	Inches	Inches	Inches	Inches	Sq. Inches	Sq. Inches	Sq. Inches	Feet	Feet	Feet	Pounds
½	.840	.252	.294	2.639	.792	.554	.050	.504	4.547	15.157	2887.164	1.714
¾	1.050	.434	.308	3.299	1.363	.866	.148	.718	3.637	8.801	973.404	2.440
1	1.315	.599	.358	4.131	1.882	1.358	.282	1.076	2.904	6.376	510.998	3.659
1¼	1.660	.896	.382	5.215	2.815	2.164	.630	1.534	2.301	4.263	228.379	5.214
1½	1.900	1.100	.400	5.969	3.456	2.835	.950	1.885	2.010	3.472	151.526	6.408
2	2.375	1.503	.436	7.461	4.722	4.430	1.774	2.656	1.608	2.541	81.162	9.029
2½	2.875	1.771	.552	9.032	5.564	6.492	2.464	4.028	1.328	2.156	58.457	13.695
3	3.500	2.300	.600	10.996	7.226	9.621	4.155	5.466	1.091	1.660	34.659	18.583
3½	4.000	2.728	.636	12.566	8.570	12.566	5.845	6.721	.954	1.400	24.637	22.850
4	4.500	3.152	.674	14.137	9.902	15.904	7.803	8.101	.848	1.211	18.454	27.541
4½	5.000	3.580	.710	15.708	11.247	19.635	10.066	9.569	.763	1.066	14.306	32.530
5	5.563	4.063	.750	17.477	12.764	24.306	12.966	11.340	.686	.940	11.107	38.552
6	6.625	4.897	.864	20.813	15.384	34.472	18.835	15.637	.576	.780	7.646	53.160
7	7.625	5.875	.875	23.955	18.457	45.664	27.109	18.555	.500	.650	5.312	63.079
8	8.625	6.877	.875	27.096	21.598	58.426	37.122	21.304	.442	.555	3.879	72.424

Standard, extra strong and double extra strong pipe for a given size have the same outside diameters. The strength of extra strong and double extra strong is secured by decreasing the inside diameter.

Pipe Couplings for Standard Wrought Iron Pipe



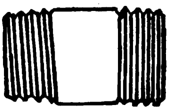
Size of Pipe	Dia. of Coupling	Length	Weight lbs.	Size of Pipe	Dia. of Coupling	Length	Weight lbs.
1/8	.562	7/8	.029	4 1/2	5.591	3 5/8	5.241
1/4	.685	1	.043	5	6.296	4 1/8	8.091
3/8	.848	1 1/8	.070	6	7.358	4 1/8	9.554
1/2	1.024	1 3/8	.116	7	8.358	4 1/8	10.932
3/4	1.281	1 5/8	.209	8	9.358	4 5/8	13.905
1	1.576	1 7/8	.343	9	10.358	5 1/8	17.236
1 1/4	1.950	2 1/8	.535	10	11.721	6 1/8	29.877
1 1/2	2.218	2 3/8	.743	11	12.721	6 1/8	32.550
2	2.760	2 5/8	1.208	12	13.958	6 1/8	43.098
2 1/2	3.276	2 7/8	1.720	13	15.208	6 1/8	47.152
3	3.948	3 1/8	2.498	14	16.446	6 1/8	59.493
3 1/2	4.591	3 5/8	4.241	15	17.446	6 1/8	63.294
4	5.091	3 5/8	4.741				

For threads per inch see table of Standard Wrought Iron Pipe.

[National Tube Co., Pittsburgh, Pa.]

Nipples for Standard Wrought Iron Pipe

(Right and left hand threads)



Short and long nipples have an unthreaded portion or shoulder as shown in figure. Close nipples have no shoulder. See table page 167.

NIPPLES (*Continued*)

Size, Inches	Length, Inches					
	*Close	*Short	Long			
1/8	3/4	1 1/2	2	2 1/2	3	3 1/2
1/4	7/8	1 1/2	2	2 1/2	3	3 1/2
3/8	1	1 1/2	2	2 1/2	3	3 1/2
1/2	1 1/8	1 1/2	2	2 1/2	3	3 1/2
3/4	1 3/8	2	2 1/2	3	3 1/2	4
1	1 1/2	2	2 1/2	3	3 1/2	4
1 1/4	1 5/8	2 1/2	3	3 1/2	4	4 1/2
1 1/2	1 3/4	2 1/2	3	3 1/2	4	4 1/2
2	2	2 1/2	3	3 1/2	4	4 1/2
2 1/2	2 1/2	3	3 1/2	4	4 1/2	5
3	2 5/8	3	3 1/2	4	4 1/2	5
3 1/2	2 3/4	4	4 1/2	5	5 1/2	6
4	2 7/8	4	4 1/2	5	5 1/2	6
4 1/2	2 7/8	4	4 1/2	5	5 1/2	6
5	3	4 1/2	5	5 1/2	6	6 1/2
6	3 1/8	4 1/2	5	5 1/2	6	6 1/2
7	3 1/4	5				
8	3 1/2	5				
9	3 5/8	5				
10	3 7/8	5				
12	4 1/2	6				

* These lengths conform to the Manufacturers' Standard.

STANDARD BOILER TUBES

Diameter		Nominal Thickness	Nearest B. W. Gauge	Circumference		Transverse Area			Length of tube per sq. ft. of		Nominal Weight Per Foot
External	Internal			External	Internal	External	Internal	Metal	External Surface	Internal Surface	
Ins.	Ins.	Ins.	No.	Ins.	Ins.	Sq. ins.	Sq. ins.	Sq. ins.	Feet	Feet	Lbs.
1 3/4	1.560	.095	13	5.498	4.901	2.405	1.911	.494	2.182	2.448	1.679
2	1.810	.095	13	6.283	5.686	3.142	2.573	.569	1.909	2.110	1.932
2 1/4	2.060	.095	13	7.069	6.472	3.976	3.333	.643	1.697	1.854	2.186
2 1/2	2.282	.109	12	7.854	7.169	4.909	4.090	.819	1.527	1.673	2.783
2 3/4	2.532	.109	12	8.639	7.955	5.940	5.036	.904	1.388	1.508	3.074
3	2.782	.109	12	9.425	8.740	7.069	6.079	.990	1.273	1.373	3.365
3 1/4	3.010	.120	11	10.210	9.456	8.296	7.116	1.180	1.175	1.269	4.011
3 1/2	3.260	.120	11	10.996	10.242	9.621	8.347	1.274	1.091	1.171	4.331
3 3/4	3.510	.120	11	11.781	11.027	11.045	9.677	1.368	1.018	1.088	4.652
4	3.732	.134	10	12.566	11.724	12.566	10.939	1.627	.954	1.023	5.532
4 1/2	4.232	.134	10	14.137	13.295	15.904	14.066	1.838	.848	.902	6.248
5	4.704	.148	9	15.708	14.778	19.635	17.379	2.256	.763	.812	7.669
6	5.670	.165	8	18.850	17.813	28.274	25.249	3.025	.636	.673	10.282
7	6.670	.165	8	21.991	20.954	38.485	34.942	3.543	.545	.572	12.044
8	7.670	.165	8	25.133	24.096	50.265	46.204	4.061	.477	.498	13.807
9	8.640	.180	7	28.274	27.143	63.617	58.629	4.988	.424	.442	16.955
10	9.594	.203	6	31.416	30.140	78.540	72.292	6.248	.381	.398	21.240
11	10.560	.220	5	34.558	33.175	95.033	87.582	7.451	.347	.361	25.329
12	11.542	.229	—	37.699	36.260	113.097	104.629	8.468	.318	.330	28.788
13	12.524	.238	4	40.840	39.345	132.732	123.190	9.542	.293	.304	32.439

Lap welded boiler tubes, as manufactured by the National Tube Co., are of open hearth steel. Sizes including 4 in. dia. are tested to 750 lbs. per sq. in. and above this size to 500.

STEEL TUBES

Cold drawn Shelby seamless steel tubes can be obtained from 3/16 in. to 9 ins. O. D.

Hot rolled can be rolled from 2 to 9 ins. They cannot be rolled smaller than 2 ins. O. D. nor with a wall thickness less than 3% of the outside diameter, provided further that the wall is not thinner than 11 gauge. Hot rolled tubes are desirable when it is necessary to machine the outside or inside to finished dimensions.

COMPARISON OF STANDARD WROUGHT IRON PIPE AND SHELBY SEAMLESS STEEL TUBING

Nominal Size Inside Diameter Wrought Iron Pipe		Nominal Weight per Foot	Nominal Thickness of Wall	Nearest Fractional Size of Seamless Steel Tubing	
Size	O. D.			O. D.	Thickness B. W. G.
1/8	.405	.244	.068	13/32	16 Ga.
1/4	.540	.424	.088	17/32	14 Ga.
3/8	.675	.567	.091	21/32	13 Ga.
1/2	.840	.850	.109	27/32	12 Ga.
3/4	1.050	1.130	.113	1 1/16	12 Ga.
1	1.315	1.678	.133	1 5/16	10 Ga.
1 1/4	1.660	2.272	.140	1 5/8	9 Ga.
1 1/2	1.900	2.717	.145	1 7/8	9 Ga.
2	2.375	3.652	.154	2 3/8	5/32
2 1/2	2.875	5.793	.203	2 7/8	6 Ga.
3	3.500	7.575	.216	3 1/2	7/32
3 1/2	4.000	9.109	.226	4	4 Ga.
4	4.500	10.790	.237	4 1/2	4 Ga.
4 1/2	5.000	12.538	.247	5	1/4
5	5.563	14.617	.258	5 5/8	9/32
6	6.625	18.974	.280	6 5/8	9/32
7	7.625	23.544	.301	7 5/8	5/16
8	8.625	28.554	.322	8 5/8	11/32
9	9.625	33.907	.342	9 5/8	11/32
10	10.750	40.483	.365	10 3/4	3/8
11	11.750	45.557	.375	11 3/4	3/8
12	12.750	49.562	.375	12 3/4	3/8

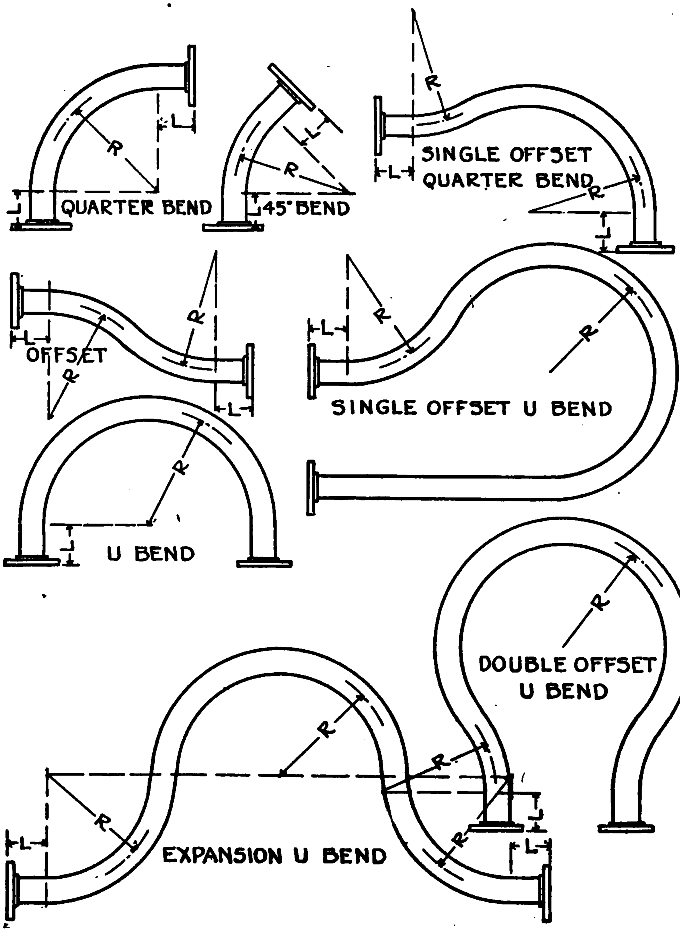
TENSILE AND PHYSICAL PROPERTIES OF SHELBY COLD DRAWN STEEL TUBES

Grade of Steel	Treatment	Minima: Yield Point Lbs. per Sq. In.	Minima: Tensile Strength Lbs. per Sq. In.	Minima: Elongation %2"	Minima: Elongation %8"	Minima: Reduction of Area %	Appearance and Condition
.17 Carbon	Temper "T" Finish Anneal	45000	58000	17	10	30	Surface dull and fairly scale free. Unless otherwise specified, material is always furnished to this temper.
.17 Carbon	Temper "U" Special Anneal	38000	52000	32	15	35	Surface dull and very slightly scaled. Material of this temper will stand a moderate amount of cold forming.
.17 Carbon	Temper "V" Medium Anneal	35000	50000	45	22	45	Surface dull and slightly scaled. Material of this temper being very soft and ductile, will stand considerable cold forming and is in excellent shape for machining. However, the tool should have a 30 deg. top rake, as the chips are long and tough.
.17 Carbon	Unannealed	55000	63000	10	3	18	Surface bright and scale free. Material of maximum strength with but slight ductility.
Boiler Tube	Temper "W"	27000	47000	50	27	50	Surface slightly scaled. This temper is suitable for all purposes; it stands cold forming and manipulation.
Boiler Tube	Temper "X"	28000	50000	52	28	52	Surface considerably scaled. Especially suitable for staybolts.
.35 Carbon	Temper "T" Finish Anneal	65000	80000	18	10	20	Surface dull and fairly scale free. Unless otherwise specified material is always furnished to this temper. It is used for mechanical purposes on parts requiring medium high tensile properties but little ductility.
35 Carbon	Temper "U" Medium Anneal	48000	65000	32	18	32	Surface dull and slightly scaled. This temper is suitable for purposes requiring medium tensile strength and ductility and shock resisting power. This temper will stand reasonable cold forming.
.35 Carbon	Unannealed	70000	85000	10	..	12	Surface bright and scale free. This material has maximum strength but hardly any ductility, and should not be used where subjected to shock. Material, provided it is not subjected to cold working or manipulation, and is to be heated above 500°C during subsequent manufacture, should be furnished to this temper.

[Tubes made by the Shelby process are manufactured by National Tube Co., Pittsburgh, Pa.]

PIPE BENDS

Lap Welded Steel Pipe



Minimum radius of pipe bend, 5 times the outside diameter of the pipe. Bends with shorter radii have practically no expansion value as they buckle in bending. All radii taken to center line of pipe.

Size of pipe, ins.	2½	3	3½	4	4½	5	6	7	8	9	10	12	14	15	16	18	20	22	24
R = minimum advisable radius, ins.....	12½	15	17½	20	22½	25	30	35	40	45	50	60	70	75	80	108	120	132	144
L = minimum tangent length ins.........	4	4	5	5	6	6	7	8	9	11	12	14	16	16	18	18	18	18	18

Copper and Steel Pipe

Minimum radius should be at least 5 times the outside diameter of the pipe.

Thickness of Steel Pipe for Bends

Up to 125 Pounds Working Pressure

Radius	Pipe Size	Pipe
4 to 5 diameters..........	7 inches and smaller..........	Extra strong
	8 inches and larger............	½ inch thick
Over 5 diameters..........	7 inches and larger............	Full weight
	8 inches.....................	28.55 pounds per foot
	10 inches.....................	40.48 pounds per foot
	12 inches.....................	49.56 pounds per foot
	14 inches to 16 inches, inclusive.	5/16 inch thick
	18 inches to 22 inches, inclusive.	3/8 inch thick
	24 inches to 30 inches, inclusive.	7/16 inch thick

125 Pounds to 250 Pounds Working Pressure

4 to 5 and 6 diameters.....	7 inches and smaller...........	Extra strong
	8 inches and larger............	½ inch thick
Over 6 diameters..........	7 inches and smaller...........	Full weight
	8 inches.....................	28.55 pounds per foot
	10 inches.....................	40.48 pounds per foot
	12 inches.....................	49.56 pounds per foot
	14 inches to 16 inches, inclusive.	3/8 inch thick
	18 inches to 22 inches, inclusive.	7/16 inch thick
	24 inches to 30 inches, inclusive.	½ inch thick

250 Pounds to 350 Pounds Working Pressure

4 diameters and over......	7 inches and smaller...........	Extra strong
	8 inches and larger............	½ inch thick

FLANGES

Standard and Low Pressure Flanges

(For pressures up to 125 lbs.)

Size Inches	Diameter of Flanges Inches	Thickness of Flanges Inches	Bolt Circle Inches	Number of Bolts	Size of Bolts Inches	Length of Bolts Inches
1	4	7/16	3	4	7/16	1½
1¼	4½	½	3⅜	4	7/16	1½
1½	5	9/16	3⅞	4	½	1¾
2	6	⅝	4¾	4	⅝	2
2½	7	11/16	5½	4	⅝	2¼
3	7½	¾	6	4	⅝	2¼
3½	8½	13/16	7	4	⅝	2½
4	9	15/16	7½	8	⅝	2¾
4½	9¼	15/16	7¾	8	¾	2¾
5	10	15/16	8½	8	¾	2¾
6	11	1	9½	8	¾	3
7	12½	1 1/16	10¾	8	¾	3
8	13½	1⅛	11¾	8	¾	3¼
9	15	1⅛	13¼	12	¾	3¼
10	16	1 3/16	14¼	12	⅞	3½
12	19	1¼	17	12	⅞	3½
14	21	1⅜	18¾	12	1	4
15	22¼	1⅜	20	16	1	4
16	23½	1 7/16	21¼	16	1	4
18	25	1 9/16	22¾	16	1⅛	4½
20	27½	1 11/16	25	20	1⅛	4¾
22	29½	1 13/16	27¼	20	1¼	5
24	32	1⅞	29½	20	1¼	5¼
26	34¼	2	31¾	24	1¼	5½
28	36½	2 1/16	34	28	1¼	5½
30	38¾	2⅛	36	28	1⅜	5¾
32	41¾	2¼	38½	28	1½	6¼
34	43¾	2 5/16	40½	32	1½	6½
36	46	2⅜	42¾	32	1½	6½
38	48¾	2⅜	45¼	32	1⅝	6¾
40	50¾	2½	47¼	36	1⅝	7

American standard in effect January 1, 1915. Flanges can be obtained in cast iron, malleable iron and cast steel. The drilling

templates are in multiples of four, so that fittings may be made to face in any quarter and bolt holes straddle the center line. Bolt holes are drilled 1/8 inch larger than nominal diameter of bolts.

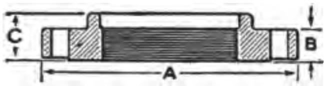
Templates for Drilling

Extra Heavy and Medium Flanged Valves and Extra Heavy Flanged Fittings—American Standard—Effective January 1, 1915.

Size in inches	Diameter in inches of Flanges	Thickness of Flanges in inches	Bolt Circle in inches	Number of Bolts	Size in inches of Bolts	Length in inches of Bolts	Length in inches of Studs with 2 Nuts
1	4 1/2	11/16	3 1/4	4	1/2	2	....
1 1/4	5	3/4	3 3/4	4	1/2	2 1/4	....
1 1/2	6	13/16	4 1/2	4	5/8	2 1/2	....
2	6 1/2	7/8	5	4	5/8	2 1/2	....
2 1/2	7 1/2	1	5 7/8	4	3/4	3	....
3	8 1/4	1 1/8	6 5/8	8	3/4	3 1/4	....
3 1/2	9	1 3/16	7 1/4	8	3/4	3 1/4	....
4	10	1 1/4	7 7/8	8	3/4	3 1/2	....
4 1/2	10 1/2	1 5/16	8 1/2	8	3/4	3 1/2	....
5	11	1 3/8	9 1/4	8	3/4	3 3/4	....
6	12 1/2	1 7/16	10 5/8	12	3/4	3 3/4	....
7	14	1 1/2	11 7/8	12	7/8	4	....
8	15	1 5/8	13	12	7/8	4 1/4	....
9	16 1/4	1 3/4	14	12	1	4 3/4	....
10	17 1/2	1 7/8	15 1/4	16	1	5	....
12	20 1/2	2	17 3/4	16	1 1/8	5 1/4	....
14	23	2 1/8	20 1/4	20	1 1/8	5 1/2	....
15	24 1/2	2 3/16	21 1/2	20	1 1/4	5 3/4	....
16	25 1/2	2 1/4	22 1/2	20	1 1/4	6	....
18	28	2 3/8	24 3/4	24	1 1/4	6 1/4	....
20	30 1/2	2 1/2	27	24	1 3/8	6 1/2	....
22	33	2 5/8	29 1/4	24	1 1/2	7	....
24	36	2 3/4	32	24	1 5/8	7 1/2	9 1/2
26	38 1/4	2 13/16	34 1/2	28	1 5/8	7 3/4	10
28	40 3/4	2 15/16	37	28	1 5/8	8	10
30	43	3	39 1/4	28	1 3/4	8 1/4	10 1/2
32	45 1/4	3 1/8	41 1/2	28	1 7/8	8 1/2	11
34	47 1/2	3 1/4	43 1/2	28	1 7/8	9	11 1/2
36	50	3 3/8	46	32	1 7/8	9 1/4	11 1/2
38	52 1/4	3 7/16	48	32	1 7/8	9 1/4	11 1/2
40	54 1/2	3 9/16	50 1/4	36	1 7/8	9 1/2	12
42	57	3 11/16	52 3/4	36	1 7/8	9 3/4	12
44	59 1/4	3 3/4	55	36	2	10	12 1/2
46	61 1/2	3 7/8	57 1/4	40	2	10 1/4	13
48	65	4	60 3/4	40	2	10 1/2	13

Extra Heavy Companion Flanges

(For pressures up to 250 lbs.)



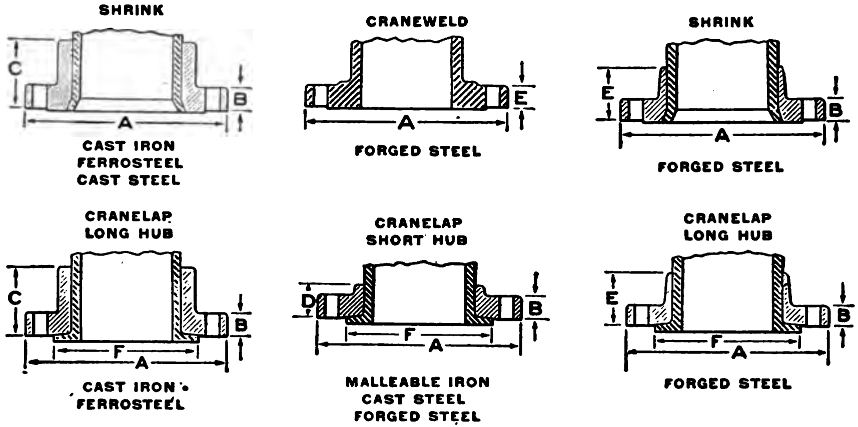
Cast iron, malleable iron, ferrosteel, cast steel, forged steel

Size .... Inches	1	1¼	1½	2	2½	3	3½	4	4½	5	6	7
A—Diameter of Flange . Inches	4½	5	6	6½	7½	8¼	9	10	10½	11	12½	14
B—Thickness of Flange . Inches	11/16	¾	13/16	⅞	1	1⅛	1 3/16	1¼	1 5/16	1⅜	1 7/16	1½
C—Length of Hub ..... Inches	1	1⅛	1¼	1⅜	1 7/16	1 9/16	1⅝	1¾	1 13/16	1⅞	2	2 1/16

Size .... Inches	8	9	10	12	14	15	16	18	20	22	24
A—Diameter of Flange . Inches	15	16¼	17½	20½	23	24½	25½	28	30½	33	36
B—Thickness of Flange . Inches	1⅝	1¾	1⅞	2	2⅛	2 3/16	2¼	2⅜	2½	2⅝	2¾
C—Length of Hub ..... Inches	2 3/16	2¼	2⅜	2 9/16	2 11/16	2 13/16	2⅞	3 1/16	3¼	3 7/16	3⅝

For drilling see page 173.
These flanges have a 1/16 in. raised face, the face having sufficient height to hold a copper gasket in place.
Sizes in effect Jan. 1, 1915, recommended by American Society of Mechanical Engineers.
Other types of extra heavy flanges are shown on page 175.

Extra Heavy Flanges



Cranelap Craneweld Shrink

Size . . . . . Inches	4	4½	5	6	7	8	9	10	12	14	15	16	18	20	22	24
A—Diameter of Flange . . . . . Inches	10	10½	11	12½	14	15	16¼	17½	20½	23	24½	25½	28	30½	33	36
B—Thickness of Flange . . . . . Inches	1¼	1 5/16	1⅜	1 7/16	1½	1⅝	1¾	1⅞	2	2⅛	2 3/16	2¼	2⅜	2½	2⅝	2¾
C—Length of Hub, Regular . . . . . Inches	3¾	3 15/16	4⅛	4¼	4 7/16	4⅝	4 13/16	4 15/16	5 5/16	5½	5⅝	6	6¼	6½	6⅞	7¼
D—Length of Hub, Short . . . . . Inches	1¾	1 13/16	1⅞	2	2 1/16	2 3/16	2¼	2⅜	2 9/16	2 11/16	2 13/16	2⅞	3 1/16	3¼	3 7/16	3⅝
E—Length of Hub, Forged Steel . . . . . Inches	3¼	3 5/16	3⅜	3 7/16	3 9/16	3¾	3 15/16	4⅛	4⅜	4¾	4⅞	5⅛	5⅜	5⅞	6⅛	6 9/16
F—Diameter of Lap . . . . . Inches	6⅝	7¼	7¾	9	10	11	12¼	13½	15¾	17⅜	18½	19½	21½	23½	25½	27½

For drilling see page 173.

BRASS AND COPPER TUBES

When ordering seamless brass and copper tubes state whether inside or outside diameter is required, otherwise outside diameter is shipped. In designating thickness, Stubs' (Birmingham Wire Gauge) or Brown and Sharpe is given. Tubes can be obtained with hard or soft temper, the latter should be specified if they are to be bent or flanged. They can be obtained in a variety of dimensions, the following table gives common sizes.

Seamless Brass* Tubes

Outside dia., ins.	Stubs' gauge—exact	Weight per foot, lbs.	Outside dia., ins.	Stubs' gauge—exact	Weight per foot, lbs.
1/8	21	.034	1 5/8	14	1.48
3/16	21	.057	1 3/4	13	1.82
1/4	20	.087	2	13	2.09
5/16	20	.112	2	16	1.45
3/8	19	.161	2 1/4	12	2.69
7/16	19	.192	2 1/4	16	1.64
1/2	18	.255	2 1/2	12	3.01
9/16	18	.290	2 1/2	16	1.83
5/8	18	.326	2 3/4	12	3.32
3/4	17	.463	3	11	3.99
7/8	17	.547	3	16	2.20
1	16	.700	3 1/4	10	4.82
1 1/8	16	.790	3 1/2	10	5.21
1 1/4	15	.98	4	10	5.98
1 3/8	14	1.24	.....	....	....
1 1/2	14	1.36	.....	....	....

*For weight of copper tubes multiply by 1.051.

Seamless brass and copper tubes are also rolled in standard iron pipe sizes 1/8, 1/4, 3/8, 1/2, 3/4, 1, 1 1/4, 1 1/2, 2, 2 1/2, 3, 3 1/2, 4, 4 1/2, 5, 6, 7, 8, 9 and 10 ins., and in extra heavy iron pipe sizes 1/8, 1/4, 3/8, 1/2, 3/4, 1, 1 1/4, 1 1/2, 2, 2 1/2, 3, 3 1/2, 4, 4 1/2, 5, 6, 7 and 8 ins. For outside and inside diameters see pages 163 and 164. Brass .307 cu. in. weighs 1 lb., copper .321 cu. in. weighs 1 lb.

FITTINGS

Standard fittings are guaranteed to 125 lbs. working pressure and extra heavy to 250 lbs.

Standard fittings and flanges are plain faced, while extra heavy inside of the bolt holes have a raised surface 1/16″ high.

In describing fittings the run is first named, then the outlet.

Length of Thread on Pipe that is Screwed into Valves or Fittings to Make a Tight Joint

Dia. of pipe	Length of thread on pipe	Dia. of pipe	Length of thread on pipe
1/8	1/4	3 1/2	1
1/4	3/8	4	1
3/8	3/8	4 1/2	1
1/2	1/2	5	1
3/4	1/2	6	1
1	5/8	7	1
1 1/4	5/8	8	1 1/4
1 1/2	5/8	9	1 1/2
2	3/4	10	1 3/4
2 1/2	7/8	12	1 3/4
3	1	....	....

Extra Heavy Cast Iron Screw Fittings

(For steam pressures up to 250 lbs.)

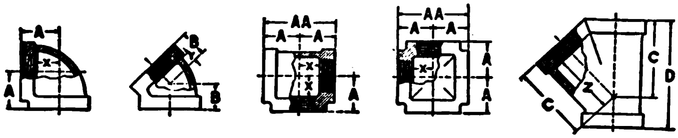
(See figures, page 178)

Size...............Inches	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2
A-Center to Face....Inches	1 5/32	1 3/8	1 19/32	1 15/16	2 1/16	2 1/2	3
AA-Face to Face.....Inches	2 5/16	2 3/4	3 3/16	3 7/8	4 1/8	5	6
B-Center to Face....Inches	3/4	7/8	1	1 3/16	1 1/4	1 1/2	1 3/4
E-Outside Diameter of Bead..........Inches	1 21/32	1 29/32	2 5/16	2 3/4	3 1/16	3 3/4	4 9/16
F-Width of Bead....Inches	7/16	1/2	9/16	11/16	3/4	7/8	1
G-Thread Length....Inches	9/16	5/8	11/16	13/16	7/8	1	1 1/8

Size...............Inches	2	3 1/2	4	4 1/2	5	6	8
A-Center to Face....Inches	3 11/16	4 1/32	4 15/32	4 27/32	5 7/32	5 13/16	7 3/16
AA-Face to Face....Inches	7 3/8	8 1/16	8 15/16	9 11/16	10 7/16	11 5/8	14 3/8
B-Center to Face....Inches	2 1/4	2 7/16	2 11/16	2 7/8	3 1/8	3 5/16	3 15/16
E-Outside Diameter of Bead..........Inches	5 3/8	6	6 13/16	7 3/8	7 15/16	9 5/16	11 9/16
F-Width of Bead....Inches	1 1/4	1 5/16	1 7/16	1 9/16	1 11/16	1 3/4	1 7/8
G-Thread Length....Inches	1 3/8	1 7/16	1 9/16	1 11/16	1 13/16	1 7/8	1 15/16

Standard Cast Iron Screw Fittings

(For steam pressures up to 125 lbs.)



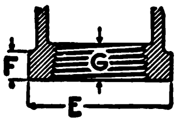
Size . . . Inches	1/4	3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3
A-Center to Face . . . Inches	3/4	7/8	1 1/16	1 5/16	1 1/2	1 13/16	2	2 3/8	2 7/8	3 5/16
AA-Face to Face . . . Inches	1 1/2	1 3/4	2 1/8	2 5/8	3	3 5/8	4	4 3/4	5 3/4	6 5/8
B-Center to Face . . . Inches	7/16	9/16	11/16	13/16	15/16	1 1/16	1 3/16	1 3/8	1 5/8	1 7/8
C-Center to Face . . . Inches	. . . .	1 7/16	1 7/8	2 1/16	2 1/2	3	3 1/4	4	5	5 5/8
D-Face to Face . . . Inches	. . . .	2 1/16	2 9/16	2 3/4	3 1/4	3 3/4	4 3/4	5 1/2	6 13/16	7 5/8
E-O.D. of Bead . . . Inches	1	1 1/8	1 7/16	1 3/4	2 1/16	2 1/2	2 3/4	3 3/8	4 1/8	4 3/4
F-Width of Bead . . . Inches	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	13/16	15/16
G-Thread Length . . . Inches	3/8	7/16	1/2	9/16	5/8	11/16	13/16	7/8	1	1

Size . . . Inches	3 1/2	4	4 1/2	5	6	7	8	9	10	12
A-Center to Face . . . Inches	3 11/16	4	4 7/16	4 11/16	5 5/16	6 1/16	6 13/16	7 1/2	8 1/4	9 9/16
AA-Face to Face . . . Inches	7 3/8	8	8 7/8	9 3/8	10 5/8	12 1/8	13 5/8	15	16 1/2	19 1/8
B-Center to Face . . . Inches	2 1/16	2 1/4	2 7/16	2 9/16	2 13/16	3 1/8	3 9/16	3 7/8	4 5/16	4 7/8
C-Center to Face . . . Inches	6 3/8	7 1/8	7 7/8	8 1/2	9 15/16	11 1/4	12 15/16	14 1/2	16	. . . .
D-Face to Face . . . Inches	8 3/4	9 3/4	10 1/2	11 5/16	13 1/8	14 5/8	16 13/16	19	20 7/8	. . . .
E-O. D. of Bead . . . Inches	5 1/4	6	6 9/16	7 1/16	8 3/8	9 3/4	10 7/8	12 1/8	13 1/4	15 5/8
F-Width of Bead . . . Inches	1	1 1/16	1 1/8	1 1/8	1 1/8	1 3/16	1 3/8	1 7/16	1 5/8	1 3/4
G-Thread Length . . . Inches	1 1/16	1 1/8	1 1/4	1 1/4	1 3/8	1 1/2	1 5/8	1 3/4	1 3/4	1 7/8

The Center to Face and Face to Face dimensions of Reducing Tees and Crosses are determined as follows: For AA-Face to Face, add to the outside diameter E of outlet bead, twice the width F of the run bead.

For A-Center to Face, add to the width F of outlet bead, one-half the diameter E of the run-bead.

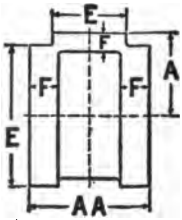
$$X = A - G$$
$$Y = B - G$$
$$Z = C - G$$



For Example AA of a 2 x 3/4 Tee equals $1\frac{3}{4} + \frac{11}{16} + \frac{11}{16} =$ $3\frac{1}{8}$ Inches.

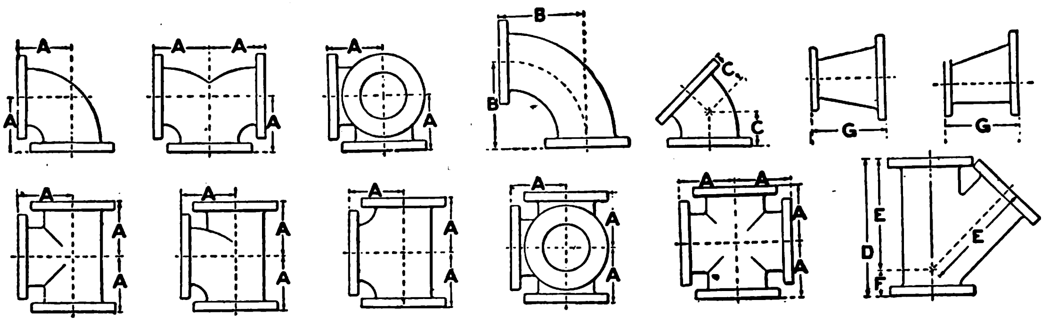
$A = \frac{7}{16} + 1\frac{11}{16} =$ $2\frac{1}{8}$ Inches.

[Walworth Mfg. Co., Boston, Mass.]



The sizes of fittings are determined by the largest opening whether in run or branch.

Standard and Low Pressure Flanged Fittings



Size	In.	1	1¼	1½	2	2½	3	3½	4	4½	5	6
AA—Face to Face, Tees and Crosses	"	7	7½	8	9	10	11	12	13	14	15	16
A—C. to F., Elbows, Tees and Crosses	"	3½	3¾	4	4½	5	5½	6	6½	7	7½	8
B—C. to F., Long Radius Elbows	"	5	5½	6	6½	7	7¾	8½	9	9½	10¼	11½
C—Center to Face, 45° Elbows	"	1¾	2	2¼	2½	3	3	3½	4	4	4½	5
D—Face to Face, Laterals	"	7½	8	9	10½	12	13	14½	15	15½	17	18
E—Center to Face, Laterals	"	5¾	6¼	7	8	9½	10	11½	12	12½	13½	14½
F—Center to Face, Laterals	"	1¾	1¾	2	2½	2½	3	3	3	3	3½	3½
G—Face to Face, Reducers	"	....	....	....	....	....	6	6½	7	7½	8	9
Diameter of Flanges	"	4	4½	5	6	7	7½	8½	9	9¼	10	11
Thickness of Flanges	"	7/16	½	9/16	⅝	11/16	¾	13/16	13/16	15/16	15/16	1

Size	In.	7	8	9	10	12	14	15	16	18	20
AA—Face to Face, Tees and Crosses	"	17	18	20	22	24	28	29	30	33	36
A—C. to F., Elbows, Tees and Crosses	"	8½	9	10	11	12	14	14½	15	16½	18
B—C. to F., Long Radius Elbows	"	12¾	14	15¼	16½	19	21½	22¾	24	26½	29
C—Center to Face, 45° Elbows	"	5½	5½	6	6½	7½	7½	8	8	8½	9½
D—Face to Face, Laterals	"	20½	22	24	25½	30	33	34½	36½	39	43
E—Center to Face, Laterals	"	16½	17½	19½	20½	24½	27	28½	30	32	35
F—Center to Face, Laterals	"	4	4½	4½	5	5½	6	6	6½	7	8
G—Face to Face, Reducers	"	10	11	11½	12	14	16	17	18	19	20
Diameter of Flanges	"	12½	13½	15	16	19	21	22¼	23½	25	27½
Thickness of Flanges	"	1 1/16	1⅛	1⅛	1 3/16	1¼	1⅜	1⅜	1 7/16	1 9/16	1 11/16

Standard and Low Pressure Flanged Fittings—*Continued*

Size	In.	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62
AA—Face to Face, Tees and Crosses	"	40	44	46	48	50	52	54	56	58	60	62	64	66	68	70	74	78	82	84	88	90
A—C. to F., Elbows, Tees and Crosses	"	20	22	23	24	25	26	27	28	29	30	31	32	33	34	35	37	39	41	42	44	45
B—C. to F., Long Radius Elbows	"	31½	34	36½	39	41½	44	46½	49	51½	54	56½	59	61½	64	66½	69	71½	74	76½	79	81½
C—Center to Face, 45° Elbows	"	10	11	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
D—Face to Face, Laterals	"	46	49½	53	56	59	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
E—Center to Face, Laterals	"	37½	40½	44	46½	49	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
F—Center to Face, Laterals	"	8½	9	9	9½	10	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
G—Face to Face, Reducers	"	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62
Diameter of Flanges	"	29½	32	34¼	36½	38¾	41¾	43¾	46	48¾	50¾	53	55¼	57¼	59½	61¾	64	66¼	68¾	71	73	75¾
Thickness of Flanges	"	1 13/16	1⅞	2	2 1/16	2⅛	2¼	2 5/16	2⅜	2⅜	2½	2⅝	2⅝	2 11/16	2¾	2¾	2⅞	3	3	3⅛	3⅛	3¼
Size	In.	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100	....	....
AA—Face to Face, Tees and Crosses	"	94	96	100	102	106	108	112	116	118	120	124	126	130	134	136	138	142	146	148	....	....
A—C. to F., Elbows, Tees and Crosses	"	47	48	50	51	53	54	56	58	59	60	62	63	65	67	68	69	71	73	74	....	....
B—C. to F., Long Radius Elbows	"	84	86½	89	91½	94	96½	99	101½	104	106½	109	111½	114	116½	119	121½	124	126½	129	....	....
C—Center to Face, 45° Elbows	"	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	....	....
G—Face to Face, Reducers	"	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100	....	....
Diameter of Flanges	"	78	80	82¼	84½	86½	88½	90¾	93	95¼	97½	99¾	102	104¼	106½	108¾	111	113¼	115½	117¾	....	....
Thickness of Flanges	"	3¼	3⅜	3⅜	3½	3½	3⅝	3⅝	3¾	3¾	3⅞	3⅞	4	4	4⅛	4⅛	4¼	4¼	4⅜	4⅜	....	....

Standard and Low Pressure Flanged Fittings are furnished plain faced unless otherwise ordered.
All reducing fittings 1 to 16″ inc. have the same face to face dimensions as straight size fittings.

Extra Heavy Flanged Fittings

Cast Iron, Ferrosteel and Cast Steel

(See figures, page 179)

Size	In.	1	1¼	1½	2	2½	3	3½	4	4½	5	6	7	8	9	10	12	14	15
AA—Face to Face, Tees and Crosses	"	8	8½	9	10	11	12	13	14	15	16	17	18	20	21	23	26	30	31
A—Center to Face, Elbows, Tees and Crosses	"	4	4¼	4½	5	5½	6	6½	7	7½	8	8½	9	10	10½	11½	13	15	15½
B—Center to Face, Long Radius Elbows	"	5	5½	6	6½	7	7¾	8½	9	9½	10¼	11½	12¾	14	15¼	16½	19	21½	22¾
C—Center to Face, 45° Elbows	"	2	2½	2¾	3	3½	3½	4	4½	4½	5	5½	6	6	6½	7	8	8½	9
D—Face to Face, Laterals	"	8½	9½	11	11½	13	14	15½	16½	18	18½	21½	23½	25½	27½	29½	33½	37½	39½
E—Center to Face, Laterals	"	6½	7¼	8½	9	10½	11	12½	13½	14½	15	17½	19	20½	22½	24	27½	31	33
F—Center to Face, Laterals	"	2	2¼	2½	2½	2½	3	3	3	3½	3½	4	4½	5	5	5½	6	6½	6½
G—Face to Face, Reducers	"	....	....	....	....	....	6	6½	7	7½	8	9	10	11	11½	12	14	16	17
Diameter of Flanges	"	4½	5	6	6½	7½	8¼	9	10	10½	11	12½	14	15	16¼	17½	20½	23	24½
Thickness of Flanges	"	11/16	¾	13/16	⅞	1	1⅛	1 3/16	1¼	1 5/16	1⅜	1 7/16	1½	1⅝	1¾	1⅞	2	2⅛	2 3/16
Size	In.	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	....
AA—Face to Face, Tees and Crosses	"	33	36	39	41	45	48	52	55	58	61	65	68	71	74	78	81	84	....
A—Center to Face, Elbows, Tees and Crosses	"	16½	18	19½	20½	22½	24	26	27½	29	30½	32½	34	35½	37	39	40½	42	....
B—Center to Face, Long Radius Elbows	"	24	26½	29	31½	34	36½	39	41½	44	46½	49	51½	54	56½	59	61½	64	....
C—Center to Face 45° Elbows	"	9½	10	10½	11	12	13	14	15	16	17	18	19	20	21	22	23	24	....
D—Face to Face, Laterals	"	42	45½	49	53	57½	....	....	....	....	....	....	....	....	....	....	....	....	....
E—Center to Face, Laterals	"	34½	37½	40½	43½	47½	....	....	....	....	....	....	....	....	....	....	....	....	....
F—Center to Face, Laterals	"	7½	8	8½	9½	10	....	....	....	....	....	....	....	....	....	....	....	....	....
G—Face to Face, Reducers	"	18	19	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	....
Diameter of Flanges	"	25½	28	30½	33	36	38¼	40¾	43	45¼	47½	50	52¼	54½	57	59¼	61½	65	....
Thickness of Flanges	"	2¼	2⅜	2½	2⅝	2¾	2 13/16	2 15/16	3	3⅛	3¼	3⅜	3 7/16	3 9/16	3 11/16	3¾	3⅞	4	....

All extra heavy flanges have a 1/16 inch raised face inside of bolt holes. This raised face is included in face to face, center to face and thickness of flange dimensions.

VALVES

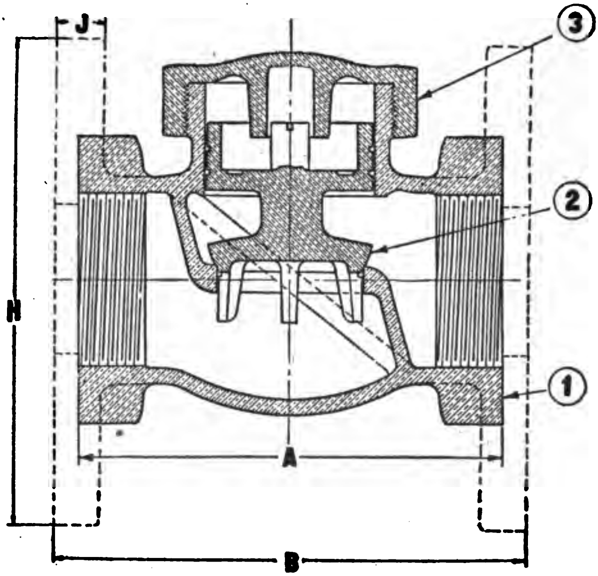
Check valves are only for use when the flow of steam or water is always in one direction. Globe and angle valves should be installed to close against pressure, for if installed the opposite way they could not be opened if the valve disc became detached from the stem. Gate valves should always have their spindles vertical.

Standard valves are for pressures up to 125 lbs., extra heavy for pressures up to 250.

Valves under 6 ins. have screwed ends, over this size the valves are generally flanged.

The following data on check, globe, angle and gate valves was supplied by Crane Co., Chicago, Ill.

Horizontal Pattern, Cushioned—Check Valve
Extra Heavy Brass

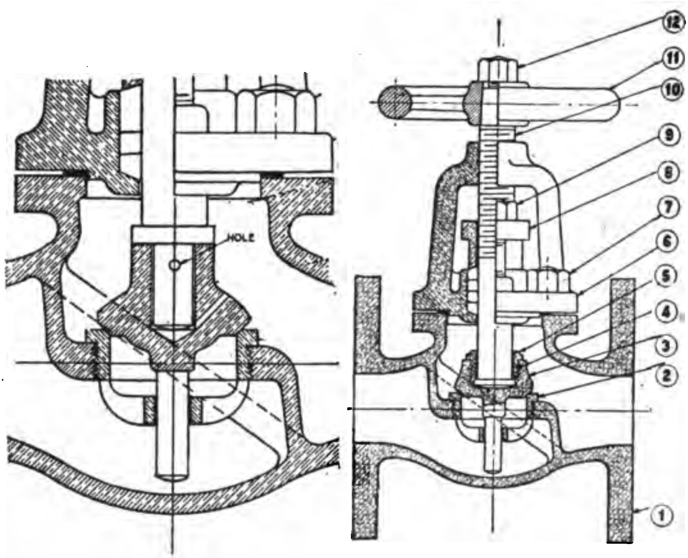


Number	Part	Number	Part
1	Body	3	Cap
2	Disc		

DIMENSIONS

Size Ins.	A	B	H	J
3/4	2 15/16	3 3/4	4	7/16
1	3 1/2	4 3/8	4 1/2	1/2
1 1/4	4 1/16	4 13/16	5	17/32
1 1/2	4 5/8	5 1/2	6	9/16
2	5 3/4	6 1/2	6 1/2	5/8

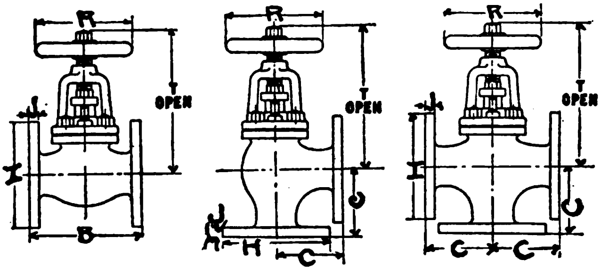
GLOBE, ANGLE AND CROSS VALVES—STOP AND SCREW DOWN CHECK



1	Body	5	Disc nut	9	Gland studs
2	Seat	6	Bonnet	10	Stem stop
3	Disc (stop)	7	Bonnet studs	11	Wheel
4	Cotter pin	8	Gland	12	Wheel nut

(*Continued on page 184*)

STOP AND SCREW DOWN CHECK VALVES—*Continued*



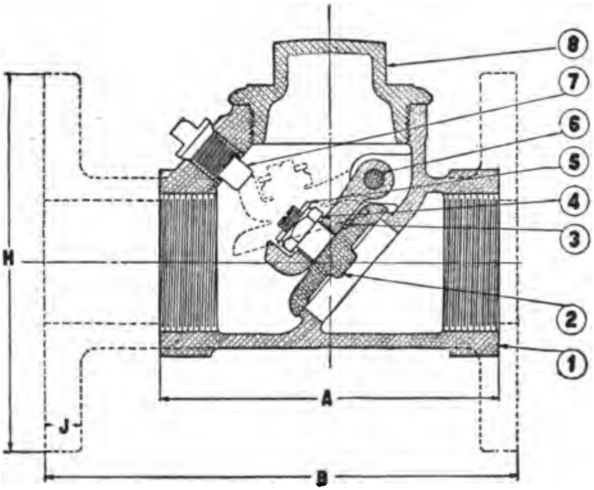
DIMENSIONS—STANDARD IRON BODY

Size Ins.	B	C	H	J	R	T
2	8	4	6	5/8	6½	11⅛
2½	8½	4¼	7	11/16	6½	11¾
3	9½	4¾	7½	¾	7½	13⅛
3½	10½	5¼	8½	13/16	7½	13⅞
4	11½	5¾	9	15/16	9	15⅜
4½	12	6	9¼	15/16	9	15½
5	13	6½	10	15/16	10	17¼
6	14	7	11	1	12	19
7	16	8	12½	1 1/16	14	21¼
8	17	8½	13½	1⅛	16	23¾
10	20	10	16	1 3/16	18	27¾
12	24	12	19	1¼	20	32½

DIMENSIONS—EXTRA HEAVY BRASS

Size Ins.	B	C	H	J	R	T
1½	6⅜	3¾	6	9/16	5½	9
2	7⅜	4⅛	6½	5/8	6½	10⅛
2½	8¾	4⅝	7½	11/16	7½	11½
3	10	5¼	8¼	¾	9	12⅞
3½	10⅞	5¾	9	13/16	9	14½
4	11½	6⅛	10	⅞	10	15¾
4½	12¼	6⅜	10½	⅞	10	16½
5	13	6¾	11	15/16	12	18
6	15	7¾	12½	1	14	22

SWINGING CHECK—EXTRA HEAVY BRASS



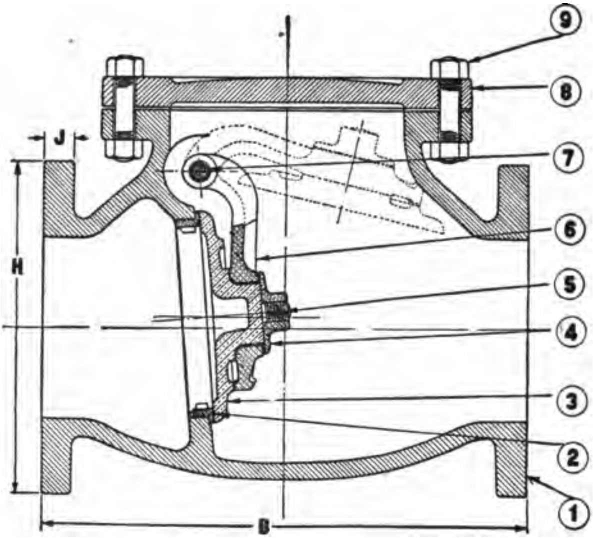
Number	Part	Number	Part
1	Body	5	Cotter pin
2	Disc	6	Hinge pin
3	Hinge	7	Stop plug
4	Disc nut	8	Cap

DIMENSIONS

Size Ins.	A	B	H	J
1	3⅝	5⅝	4½	½
1¼	4⅛	6¼	5	17/32
1½	4 13/16	7 3/16	6	9/16
2	5 13/16	8⅛	6½	⅝

In the valve shown, the swing of the disc can be controlled by the plug stop.

Swinging Check—Standard Iron Body

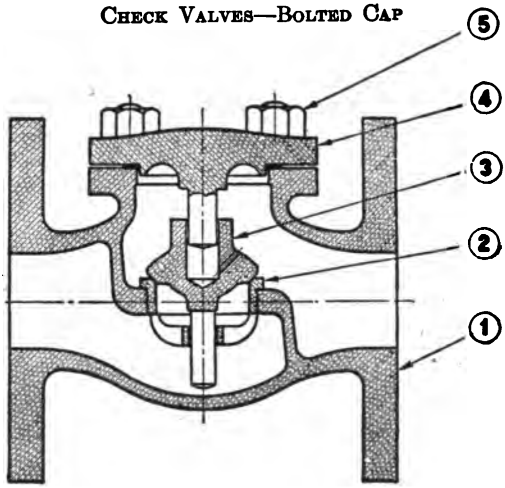


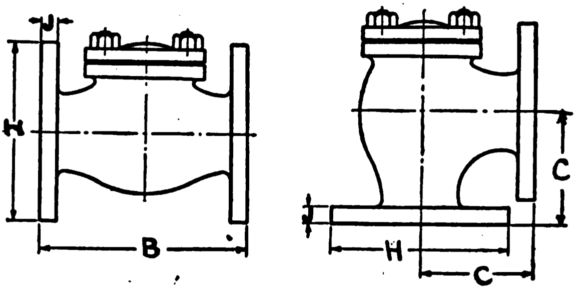
Number	Part	Number	Part
1	Body	6	Hinge
2	Seat	7	Hinge pin
3	Disc	8	Cap
4	Disc nut	9	Cap bolts
5	Disc pin		

Dimensions

Size Ins.	B	H	J	Size Ins.	B	H	J
2½	10	7	11/16	6	16	11	1
3	11	7½	¾	8	18	13½	1⅛
4	13	9	15/16	10	22	16	1 3/16
5	15	10	15/16	12	26	19	1¼

Check Valves—Bolted Cap





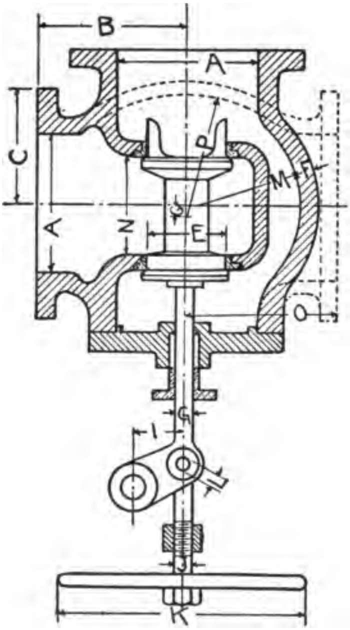
Horizontal and angle pattern, bolted bonnet, extra heavy brass

Number	1	2	3	4	5
Part	Body	Seat	Disc	Cap	Cap Studs

Dimensions

Size, Inches.	B	C	H	J
1½	6⅜	3¾	6	9/16
2	7⅜	4⅛	6½	⅝
2½	8¾	4⅝	7½	11/16
3	10	5¼	8¼	¾

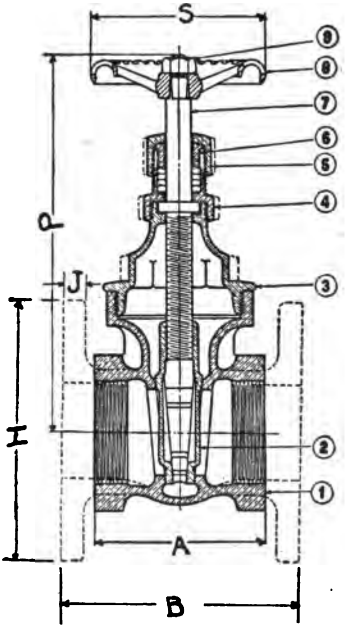
Throttle Valves



A	B	C	E	F	G	I	J	K	L	M	N	Lift of valve
4	6 1/4	6 1/4	3 5/8	5/8	1	2 1/2	...	..	7/8	4 5/16	2 1/2	1 1/4
5	7 1/4	....	4 3/16	7/16	1 1/8	2 31/32	7/8	8	7/8	....	3	1
5 1/2	7 1/4	....	4 3/16	7/16	1 1/8	2 31/32	7/8	8	7/8	....	3	1
6 1/2	8 1/2	8 1/2	5 1/2	3/4	1 1/4	3 5/8	...	..	1 1/8	6 1/4	3 1/2	1 1/4
8 1/2	9 3/4	9 3/4	7	7/8	1 5/8	4	1 1/8	9	1 1/2	7 3/4	4 1/2	2
9	11	11	7 1/4	7/8	1 1/2	4	...	..	1 1/2	8 3/4	6	2
11	11 1/2	11 1/2	8 1/4	1	1 5/8	4	1 1/8	9	1 1/2	9 1/2	6 1/2	2 1/2
12	14	16 1/2	9 1/16	1 1/4	1 5/8	2 7/8	1 1/4	10	1 1/2	11 1/2	7	2 1/4
13	19	12 5/8	9 3/4	11/16	1 5/8	3	1 1/4	..	1 1/2	....	9	2 13/32

All dimensions in inches. Valve shown operated either by wheel K or by lever I.

Gate Valves



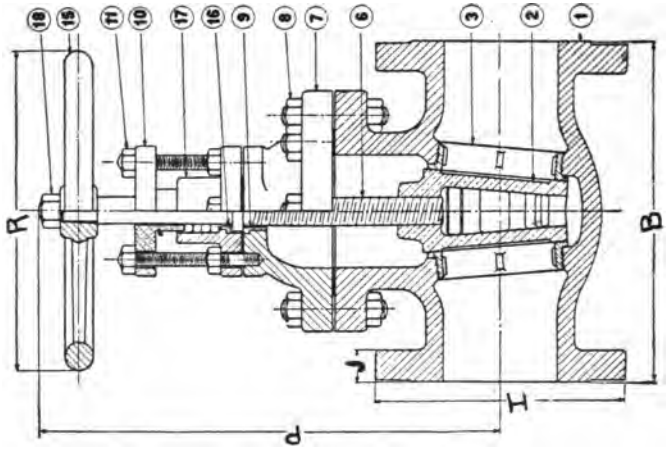
Standard Brass—Non-Rising Stem

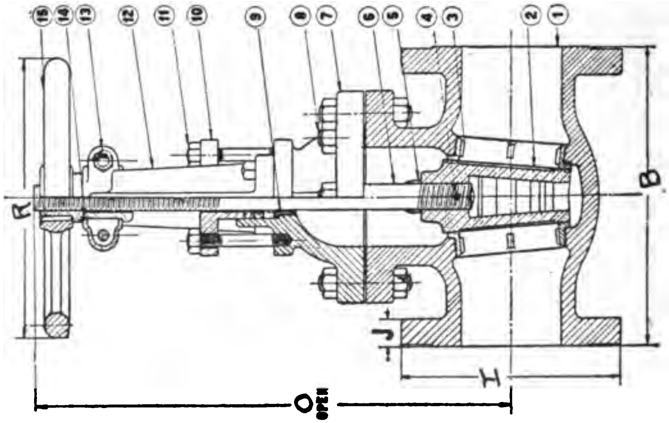
Number	Part	Number	Part
1	Body	6	Gland
2	Disc	7	Stem
3	Bonnet	8	Wheel
4	Stuffing box	9	Wheel nut
5	Stuffing nut		

Dimensions

Size Ins.	A	B	H	J	P	S
1	$2\frac{5}{8}$	$3\frac{3}{8}$	4	$\frac{3}{8}$	$5\frac{7}{16}$	$2\frac{3}{4}$
$1\frac{1}{4}$	$2\frac{15}{16}$	$3\frac{7}{8}$	$4\frac{1}{2}$	$\frac{13}{32}$	$6\frac{7}{16}$	$3\frac{1}{16}$
$1\frac{1}{2}$	$3\frac{1}{4}$	$4\frac{3}{8}$	5	$\frac{7}{16}$	$7\frac{1}{4}$	$3\frac{5}{8}$
2	$3\frac{29}{32}$	$5\frac{1}{2}$	6	$\frac{1}{2}$	$8\frac{3}{4}$	$4\frac{1}{16}$

Iron Body—Rising and Non-Rising Stem





Number	Part	Number	Part
1	Body	5	Stem ring
2	Disc	6	Stem
3	Body ring	7	Bonnet
4	Pin	8	Bonnet bolts

Number	Part	Number	Part
9	Bonnet bushing	14	Yoke sleeve
10	Gland	15	Wheel
11	Gland studs	16	Stuffing box bushing
12	Yoke	17	Stuffing box
13	Yoke bolts	18	Wheel nut

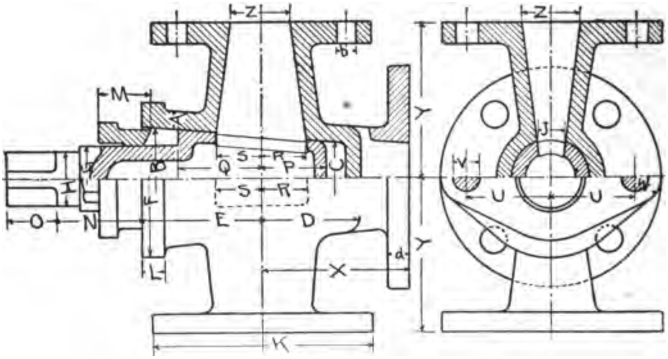
Standard Dimensions

Size Ins.	B	H	J	O	P	R
2	7	6	5/8	14½	11¾	6½
2½	7½	7	11/16	16	12¾	6½
3	8	7½	¾	19	14¼	7½
3½	8½	8½	13/16	21¼	15¼	7½
4	9	9	15/16	24	16¼	9
4½	9½	9¼	15/16	25½	17⅝	9
5	10	10	15/16	28½	19	10
6	10½	11	1	31¾	20¾	12
7	11	12½	1 1/16	37¼	23	12
8	11½	13½	1⅛	41	26	14
9	12	15	1⅛	44¾	28	14
10	13	16	1 3/16	50	30¼	16
12	14	19	1¼	57¼	35¼	18

Extra Heavy Dimensions

Size Ins.	B	H	J	O	P	R
1¼	6½	5	¾	10⅝	8¾	5
1½	7½	6	13/16	12¼	9⅝	5½
2	8½	6½	⅞	13¾	10½	6½
2½	9½	7½	1	16	12⅞	7½
3	11⅛	8¼	1⅛	19½	14⅝	9
3½	11⅞	9	1 3/16	22	15½	10
4	12	10	1¼	24½	17¾	12
4½	13¼	10½	1 5/16	27	18¾	12
5	15	11	1⅜	29¾	20¼	14
6	15⅞	12½	1 7/16	34⅛	23	16
7	16¼	14	1½	38	24¾	18
8	16½	15	1⅝	42¾	28¾	20
9	17	16¼	1¾	47	30½	20
10	18	17½	1⅞	52¾	33¾	22
12	19¾	20½	2	60	37¼	24

COCKS

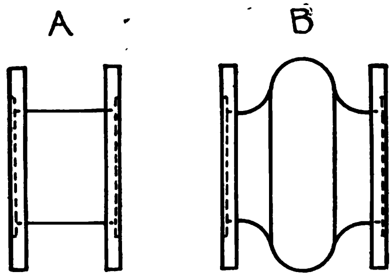


Size of Cock Z	1	1 1/4	1 1/2	2	2 1/2	3	3 1/2	4
Dimensions								
A	1/4	1/4	1/4	5/16	3/8	7/16	7/16	7/16
B	1 7/8	2 1/4	2 1/4	3 1/2	4 1/8	4 3/4	5 5/8	6 1/8
C	1 3/8	1 5/8	1 7/8	2 1/2	3	3 1/2	4 1/8	4 5/8
D	1 5/8	1 7/8	1 15/16	2 1/2	2 7/8	3 1/8	3 11/16	4
E	2 1/8	2 5/16	2 1/2	3 1/8	3 5/8	4 1/16	4 5/8	4 13/16
F	2 5/8	3	3 3/8	4 1/2	5	5 3/4	7	7 1/2
G	1 1/4	1 1/2	1 3/4	2 5/8	3	3 5/8	4 3/8	4 7/8
H	1	1 1/8	1 1/8	1 5/8	1 3/4	2 1/2	2 1/2	2 1/2
J	5/8	3/4	7/8	1 1/4	1 1/2	1 7/8	2 1/8	2 1/2
K	4	4 1/2	5	6	7	7 1/2	8 1/2	9
L	5/8	7/8	1 1/8	1 5/16	1 3/4	2 1/8	2 1/2	2 3/4
M	1 1/8	1 1/8	1 1/4	1 1/2	1 5/8	1 3/4	1 7/8	2
N	1 3/8	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	1 7/8	1 7/8
O	7/8	7/8	1	1 1/4	1 1/2	1 5/8	2	2
P	1 3/16	1 5/16	1 3/8	1 7/8	2 3/16	2 1/2	2 7/8	3 3/16
Q	1 3/8	1 5/8	1 3/4	2 1/4	2 5/8	3	3 3/8	3 3/4
R	11/16	13/16	7/8	1 1/4	1 7/16	1 3/4	2	2 5/16
S	7/8	7/8	1 1/8	1 1/2	1 3/4	2 1/16	2 3/8	2 11/16
U	1 7/16	1 5/8	1 13/16	2 7/16	2 3/4	3 3/16	3 5/8	3 15/16
V	1/2	1/2	1/2	5/8	3/4	3/4	3/4	3/4
W	9/16	9/16	9/16	3/4	7/8	7/8	7/8	7/8
X	2 5/8	2 5/8	2 3/4	3 5/8	4	4 3/8	5 1/4	5 3/8
Y	2 5/8	2 3/4	2 7/8	3 3/4	4 1/4	4 5/8	5 3/8	5 1/2
b	7/16	7/16	1/2	5/8	5/8	5/8	5/8	5/8
Number of bolts	4	4	4	4	4	4	4	8
Dia. of bolt circle	3	3 3/8	3 7/8	4 3/4	5 1/2	6	7	7 1/2
d	3/8	7/16	7/16	1/2	1/2	9/16	5/8	5/8

EXPANSION JOINTS

Of the joints shown on the following pages, the copper expansion joints are for pressures up to 25 lbs., while those of the stuffing box type are for higher pressures as in main steam lines.

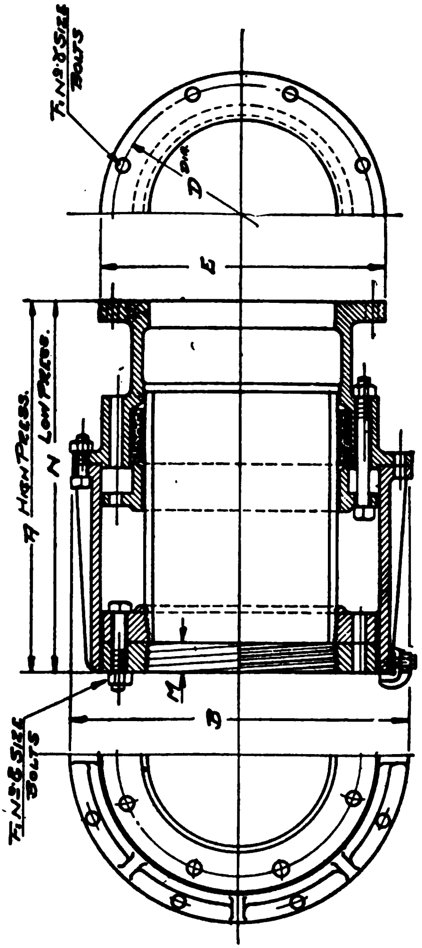
Copper Expansion Joints



Copper expansion joints A and B are recommended where the expansion and contraction does not exceed ¼ in. A is particularly suitable for high vacuum systems. Besides the joints shown there are others made of corrugated copper which may be used for pressures higher than 25 lbs. Pipe lines must be anchored to force the joints to compensate for the expansion and contraction in the pipe.

Size of pipe	Face to face of flanges		Dia. of flanges	Size of pipe	Face to face of flanges		Dia. of flanges
	Type A	Type B			Type A	Type B	
4	5½	8	9	14	6	12	21
5	5½	9	10	15	6	12	22¼
6	6	9	11	16	6	12	23½
7	6	10	12½	18	6½	13	25
8	6	10	13½	20	6½	13	27½
9	6	11	15	22	7	14	29½
10	6	11	16	24	7	14	32
12	6	11	19	26	8	15	34¼

[Crane Co., Chicago, Ill.]

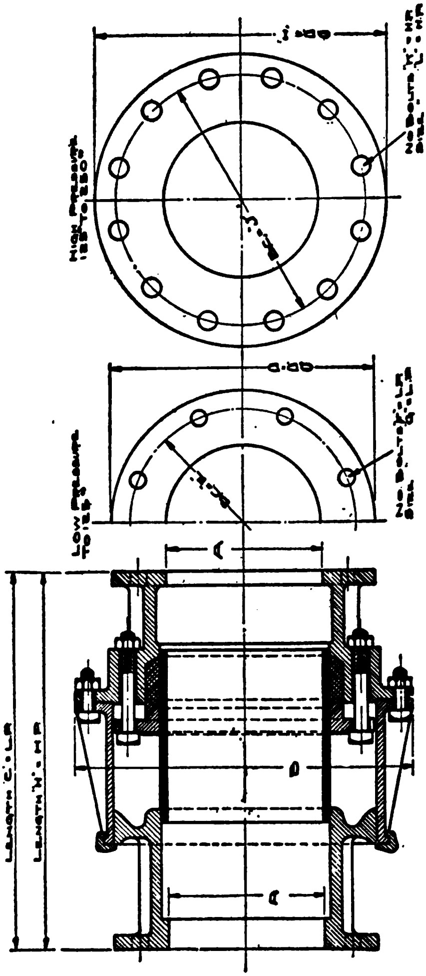


Guided Expansion Joint

Type A

Pipe Size	1 1/4	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5	6	7	8	9	10	12
A 4" Trav	15 19/32	15 19/32	16 1/8	16 15/32	17 1/4	17 1/2	17 29/32	18 11/32	18 15/32	18 17/32	19 15/16	21 1/4	21 3/8	25 7/16	25 1/2
A 8" Trav	23 15/32	23 15/32	23 15/16	24 11/32	25 1/8	25 3/8	25 27/32	26 1/32	26 15/32	26 11/32	26 31/32	28 13/32	28 3/4	30 19/32	30 15/16
A 12" Trav	31 15/32	31 15/32	31 15/16	32 11/32	33 1/8	33 3/8	33 27/32	34 1/32	34 7/32	34 11/32	34 31/32	36 13/32	36 3/4	38 19/32	38 15/16
B	7 7/8	7 7/8	9 1/8	9 5/8	11 1/8	12	12	12 1/2	13 1/4	14 1/4	16 1/2	17 3/8	18 3/8	20 3/4	22 1/2
D High Press	3 3/4	4 1/2	5	5 7/8	6 5/8	7 1/4	7 7/8	8 1/2	9 1/4	10 5/8	11 7/8	13	14	15 1/4	17 3/4
E High Press	5	6	6 1/2	7 1/2	8 1/4	9	10	10 1/2	11	12 1/2	14	15	16 1/4	17 1/2	20 1/2
F High Press	4–1/2	4–5/8	4–5/8	4–3/4	8–3/4	8–3/4	8–3/4	8–3/4	8–3/4	12–3/4	12–7/8	12–7/8	12–1	16–1	16–1 1/8
D Low Press	3 3/8	3 7/8	4 3/4	5 1/2	6	7	7 1/2	7 3/4	8 1/2	9 1/2	10 3/4	11 3/4	13 1/4	14 1/4	17
E Low Press	4 1/2	5	6	7	7 1/2	8 1/2	9	9 1/4	10	11	12 1/2	13 1/2	15	16	19
F Low Press	4–7/16	4–1/2	4–5/8	4–5/8	4 5/8	4 5/8	8–5/8	8–3/4	8–3/4	8–3/4	8–3/4	8–3/4	12–3/4	12–7/8	12–7/8
M	7/8	7/8	7/8	1	1 1/8	1 3/16	1 1/4	1 5/16	1 3/8	1 7/16	1 1/2	1 5/8	1 3/4	1 7/8	2
N 4" Trav	15 11/32	15 11/32	15 7/8	16 5/32	16 7/8	17 1/8	17 19/32	17 31/32	18 1/32	18 3/32	19 1/2	20 3/4	20 3/4	24 3/4	24 3/4
N 8" Trav	23 7/32	23 7/32	23 11/16	24 1/32	24 3/4	25	25 17/32	25 21/32	26 1/32	25 29/32	26 19/32	27 29/32	28 1/8	29 29/32	30 3/16
N 12" Trav	31 7/32	31 7/32	31 11/16	32 1/32	32 3/4	33	33 17/32	33 21/32	33 25/32	33 29/32	34 17/32	35 29/32	36 1/8	37 29/32	38 3/16

[Howard Iron Works, Buffalo, N. Y.]

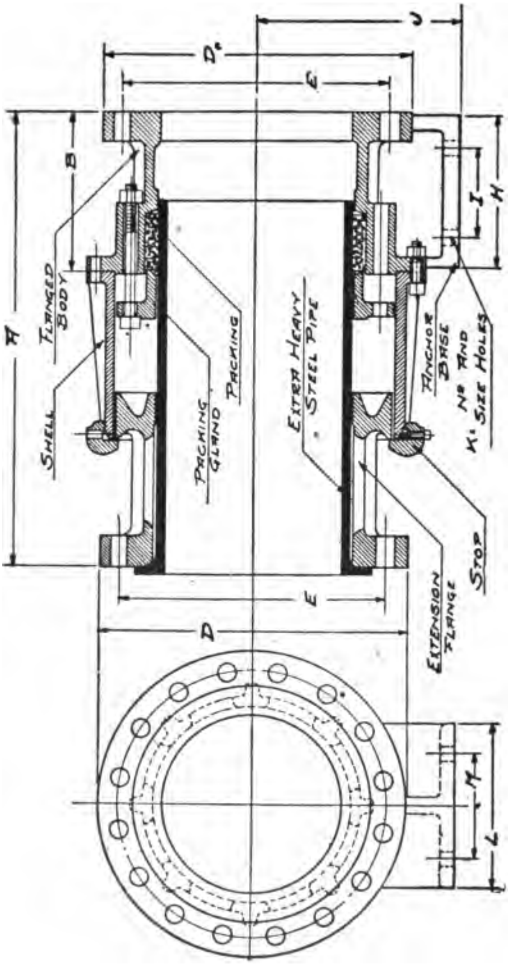


GUIDED EXPANSION JOINT WITH EXTENSION FLANGE

TYPE B

	A—Size of Pipe	1¼	1½	2	2½	3	3½	4	4½	5	6	7	8	9	10	12
Low Press.	B = Diam. of Joint	7 7/8	7 7/8	9 1/8	9 5/8	11 1/8	12	12	12 1/2	13 1/4	14 1/4	16 1/2	17 3/8	18 3/8	20 3/4	22 1/2
	C = Length of 4″ Travel	21 15/16	22 1/16	22 5/8	22 7/8	23 1/2	24 7/16	24 7/8	25 5/16	25 3/8	25 7/16	27 1/4	28 5/8	29	33 1/8	33 3/8
	C = Length of 8″ Travel	33 9/16	33 11/16	34 7/16	34 3/4	35 7/16	35 13/16	36 5/16	36 5/8	37 3/8	36 7/8	37 7/8	38 15/16	39 5/16	41 5/8	41 15/16
	C = Length of 12″ Travel	45 9/16	45 11/16	46 7/16	46 3/4	47 7/16	47 13/16	48 5/16	48 5/8	48 3/4	48 7/8	49 7/8	50 15/16	51 5/16	53 5/8	53 15/16
	D = Diam. Flange	4 1/2	5	6	7	7 1/2	8 1/2	9	9 1/4	10	11	12 1/2	13 1/2	15	16	19
	E = Bolt Circle	3 3/8	3 7/8	4 3/4	5 1/2	6	7	7 1/2	7 3/4	8 1/2	9 1/2	10 3/4	11 3/4	13 1/4	14 1/4	17
	F = No. Bolts	4	4	4	4	4	4	8	8	8	8	8	8	12	12	12
	G = Size of Bolts	7/16	1/2	5/8	5/8	5/8	5/8	5/8	3/4	3/4	3/4	3/4	3/4	3/4	7/8	7/8
High Press.	H = Length of 4″ Travel	21 15/16	22 1/16	22 5/8	22 7/8	23 1/2	24 7/16	24 7/8	25 5/16	25 3/8	25 7/16	27 1/4	28 5/8	29	33 1/8	33 3/8
	H = Length of 8″ Travel	33 9/16	33 11/16	34 7/16	34 3/4	35 7/16	35 13/16	36 5/16	36 5/8	37 3/8	36 7/8	37 7/8	38 15/16	39 5/16	41 5/8	41 15/16
	H = Length of 12″ Travel	45 9/16	45 11/16	46 7/16	46 3/4	47 7/16	47 13/16	48 5/16	48 5/8	48 3/4	48 7/8	49 7/8	50 15/16	51 5/16	53 5/8	53 15/16
	I = Diam. Flange	5	6	6 1/2	7 1/2	8 1/4	9	10	10 1/2	11	12 1/2	14	15	16 1/4	17 1/2	20 1/2
	J = Bolt Circle	3 3/4	4 1/2	5	5 7/8	6 5/8	7 1/4	7 7/8	8 1/2	9 1/4	10 5/8	11 7/8	13	14	15 1/4	17 3/4
	K = No. Bolts	4	4	4	4	8	8	8	8	8	12	12	12	12	16	16
	L = Size of Bolts	1/2	5/8	5/8	3/4	3/4	3/4	3/4	3/4	3/4	3/4	7/8	7/8	1	1	1 1/8

[Howard Iron Works, Buffalo, N. Y.]



GUIDED EXPANSION JOINT WITH VAN STONE FLANGE

TYPE C

	High Pressure								Both Pressures						Low Pressure								
	4" Trav'se		8" Trav'se		12" Trav'se		All Trav'ses		All Trav'ses							4" Trav'se		8" Trav'se		12" Trav'se		All Trav'ses	
Pipe Size	A	B	A	B	A	B	D	E	H	I	J	K	L	M	Pipe Size	A	B	A	B	A	B	D	E
1 1/4	22 9/32	7 1/2	34 5/32	11 3/8	46 5/32	15 3/8	5	3 3/4	6 7/8	3 1/2	5 1/2	4-9/16	5	3	1 1/4	22 1/32	7 1/4	33 29/32	11 1/8	45 29/32	15 1/8	4 1/2	3 3/8
1 1/2	22 13/32	7 1/2	34 9/32	11 3/8	46 9/32	15 3/8	6	4 1/2	6 7/8	3 1/2	5 1/2	4-9/16	5	3	1 1/2	22 1/32	7 1/4	33 29/32	11 1/8	45 29/32	15 1/8	5	3 7/8
2	23	7 7/8	34 13/16	11 11/16	46 13/16	15 11/16	6 1/4	5	7 5/8	3 1/2	6 1/2	4-5/8	6	4	2	22 3/4	7 5/8	34 9/16	11 7/16	46 9/16	15 7/16	6	4 3/4
2 1/2	23 19/32	7 15/16	35 15/32	11 13/16	47 15/32	15 13/16	7 1/2	5 7/8	7 5/8	3 1/2	7	4-5/8	6 1/2	4	2 1/2	23 9/32	7 5/8	35 5/32	11 1/2	47 5/32	15 1/2	7	5 1/2
3	24 1/2	8 5/16	36 3/8	12 3/16	48 3/8	16 3/16	8 1/4	6 5/8	7 3/4	3 1/2	7 1/2	4-5/8	6 1/2	4	3	24 1/8	7 15/16	36	11 13/16	48	15 13/16	7 1/2	6
3 1/2	24 13/16	8 3/8	36 11/16	12 1/4	48 11/16	16 1/4	9	7 1/4	7 5/8	3 1/2	7 1/2	4-5/8	7	4	3 1/2	24 7/16	8	36 5/16	11 7/8	48 5/16	15 7/8	8 1/2	7
4	25 9/32	8 11/16	37 7/32	12 5/8	40 7/32	16 5/8	10	7 7/8	8	4	8	4-3/4	7 1/2	4 1/2	4	24 31/32	8 3/8	36 29/32	12 5/16	48 29/32	16 5/16	9	7 1/2
4 1/2	25 5/32	9	37 15/32	12 11/16	49 15/32	16 11/16	10 1/2	8 1/2	8 1/8	4 1/2	8 1/2	4-3/4	8	5	4 1/2	25 13/32	8 5/8	37 3/32	12 5/16	49 3/32	16 5/16	9 1/4	7 3/4
5	25 31/32	9 1/16	37 31/32	13 1/16	49 23/32	16 13/16	11	9 1/4	8 1/8	4 1/2	8 1/2	4-3/4	8	5	5	25 17/32	8 5/8	37 17/32	12 5/8	49 9/32	16 3/8	10	8 1/2
6	26 3/32	9 1/16	37 29/32	12 7/8	49 29/32	16 7/8	12 1/2	10 5/8	8 1/8	4 1/2	8 1/2	4-3/4	8	5	6	25 21/32	8 5/8	37 15/32	12 7/16	49 15/32	16 7/16	11	9 1/2
7	27 11/16	9 9/16	38 3/32	13 3/16	50 23/32	17 3/16	14	11 7/8	8 3/4	5	10 1/4	4-3/4	9	5	7	27 1/4	9 1/2	38 9/32	12 3/4	50 9/32	16 3/4	12 1/2	10 3/4
8	29 1/8	10 1/4	40 9/32	13 15/16	52 9/32	17 15/16	15	13	9 1/4	5	10 1/2	4-7/8	9	6	8	28 5/8	9 3/4	39 25/32	13 7/16	51 25/32	17 7/16	13 1/2	11 3/4
9	29 5/8	10 3/8	41	14 1/16	53	18 1/16	16 1/4	14	9 1/4	5	11 1/2	4-7/8	9 1/4	6	9	29	9 3/4	40 3/8	13 7/16	52 3/8	17 7/16	15	13 1/4
10	33 13/16	11 7/16	42 31/32	15 1/16	54 31/32	19 1/16	17 1/2	15 1/4	10 1/4	6	12 1/2	4-1	10	7	10	33 1/8	10 3/4	41 9/32	14 3/8	54 9/32	18 3/8	16	14 1/4
12	34 1/8	11 1/2	43 9/16	15 3/16	55 9/16	19 5/16	20 1/2	17 3/4	10 1/4	6	13 1/2	4-1	11	7	12	33 3/8	10 3/4	42 13/16	14 7/16	54 13/16	18 7/16	19	17

[Howard Iron Works, Buffalo, N. Y.]

SECTION V

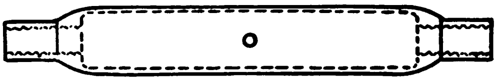
ROPE AND CHAIN FITTINGS

TURNBUCKLES—SLEEVE NUTS—THIMBLES—SOCKETS—WIRE ROPE—SHACKLES — SISTER HOOKS — CLEVIS NUTS — EYE BOLTS — HOOKS—SLINGS—ROPE AND CHAIN—CHAIN-HOISTING AND ANCHOR—DRUM SCORES FOR CHAIN AND ROPE

TURNBUCKLES

Turnbuckles may have rods with eye or hook ends of sizes shown on pages 211 and 212, one of which is threaded right hand and the other left.

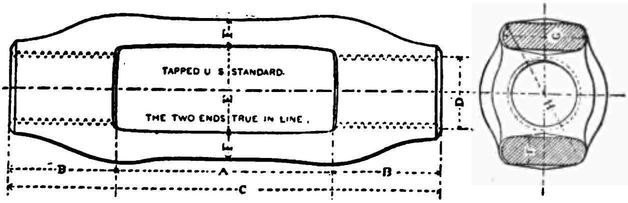
PIPE TURNBUCKLES



Dia. of screw	Threads per in.	Size of pipe*	Overall length of turnbuckle	Length of screw end	Dia. of screw end
3/8	16	1/2	5	5/8	3/4
1/2	13	3/4	5 1/2	7/8	1
5/8	11	1	7	1 1/8	1 1/4
3/4	10	1	7	1 1/8	1 1/2
7/8	9	1 1/4	8	1 1/4	1 3/4
1	8	1 1/2	9 1/2	1 1/2	2

* See page 163. Hole for pin 1/4 in. dia.

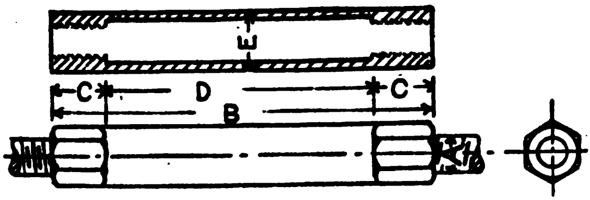
Turnbuckles with Plain Stubs



Size D Out. Dia. Screw, Inches	A Inches	B Inches	C Inches	E Inches	H Inches	F Inches	G Inches
3/8	6	9/16	7 1/8	9/16	1 1/16	3/16	1/2
7/16	6	21/32	7 5/16	5/8	1 3/8	1/4	5/8
1/2	6	3/4	7 1/2	5/8	1 3/8	1/4	5/8
9/16	6	27/32	7 11/16	13/16	1 9/16	5/16	3/4
5/8	6	15/16	7 7/8	13/16	1 9/16	5/16	3/4
3/4	6	1 1/8	8 1/4	1 1/16	2	11/32	7/8
7/8	6	1 5/16	8 5/8	1 1/4	2 1/4	3/8	1
1	6	1 1/2	9	1 5/16	2 7/16	7/16	1 1/4
1 1/8	6	1 11/16	9 3/8	1 7/16	2 9/16	1/2	1 1/4
1 1/4	6	1 7/8	9 3/4	1 9/16	2 3/4	1/2	1 1/2
1 3/8	6	2 1/16	10 1/8	1 11/16	3 1/16	1/2	1 5/8
1 1/2	6	2 1/4	10 1/2	1 3/4	3 3/16	5/8	1 3/4
1 5/8	6	2 7/16	10 7/8	2	3 1/2	5/8	1 7/8
1 3/4	6	2 5/8	11 1/4	2 1/8	3 3/4	5/8	2
1 7/8	6	2 13/16	11 5/8	2 3/16	3 7/8	11/16	2 1/8
2	6	3	12	2 3/8	4 1/4	11/16	2 1/4
2 1/8	6	3 3/16	12 3/8	2 1/2	4 1/2	23/32	2 1/2
2 1/4	6	3 3/8	12 3/4	2 11/16	4 3/4	13/16	2 1/2
2 3/8	6	3 9/16	13 1/8	2 3/4	4 1/4	13/16	2 3/4
2 1/2	6	3 3/4	13 1/2	3 1/16	5 3/8	27/32	3
2 5/8	6	3 15/16	13 7/8	3 1/8	5 9/16	15/16	3
2 3/4	6	4 1/8	14 1/4	3 1/4	5 3/4	15/16	3 1/4
2 7/8	6	4 5/16	14 5/8	3 7/16	6 1/16	1 1/32	3 1/4
3	6	4 1/2	15	3 5/8	6 3/8	1 1/32	3 1/2
3 1/4	6	4 7/8	15 3/4	3 3/4	7	1 1/4	4
3 1/2	6	5 1/4	16 1/2	3 7/8	7 1/2	1 5/16	4 1/2
3 3/4	6	5 5/8	17 1/4	4 1/8	8 3/8	1 7/16	5
4	6	6	18	4 5/8	9 3/8	1 5/8	5 1/8
4 1/4	9	6 1/4	21 1/2	5	10 1/8	1 5/8	6
4 1/2	9	6 3/4	22 1/2	5 3/8	10 1/4	1 3/4	6 1/2
4 3/4	9	7 1/4	23 1/2	5 1/2	11 3/8	2	6 1/2
5	9	7 1/2	24	5 7/8	12	2 1/4	6 1/2

[Cleveland City Forge & Iron Co., Cleveland, O.]

Hexagon End Pipe Turnbuckles

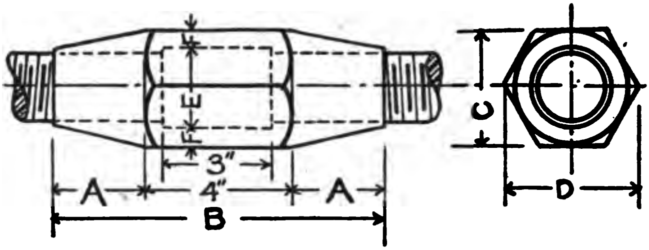


Diameter of Screw A	Threads per Inch	Length of Swivel B	Length between Heads D	Length of Heads C	Outside diameter of Pipe E
		in.	in.	in.	in.
3/8	16	5	3 3/4	5/8	.840
1/2	13	5 1/2	3 3/4	7/8	1.050
5/8	11	7	4 3/4	1 1/8	1.315
3/4	10	7	4 3/4	1 1/8	1.315
7/8	9	8	5 1/2	1 1/4	1.660
1	8	9 1/2	6 1/2	1 1/2	1.900
1 1/8	7	9 1/2	6	1 3/4	1.900
1 1/4	7	11 1/2	8	1 3/4	2.375
1 3/8	6	11 1/2	8	1 3/4	2.375
1 1/2	6	13 1/2	8 1/2	2 1/2	2.875
1 5/8	5 1/2	13 1/2	8 1/2	2 1/2	2.875
1 3/4	5	13 1/2	8 1/2	2 1/2	2.875
1 7/8	5	15	9 1/2	2 3/4	3.500
2	4 1/2	15	9 1/2	2 3/4	3.500
2 1/8	4 1/2	15	9 1/2	2 3/4	3.500
2 1/4	4 1/2	16 1/2	11	2 3/4	4.000
2 3/8	4	16 1/2	11	2 3/4	4.000
2 1/2	4	18 1/2	12	3 1/4	4.500
2 3/4	4	18 1/2	12	3 1/4	4.500
3	3 1/2	19 1/2	12 3/4	3 3/8	5.000

[Hoopes & Townsend Co., Philadelphia, Pa.]

With this type of turnbuckle a wrench with an hexagonal opening (page 238) is required to turn it.

HEXAGON SLEEVE NUTS

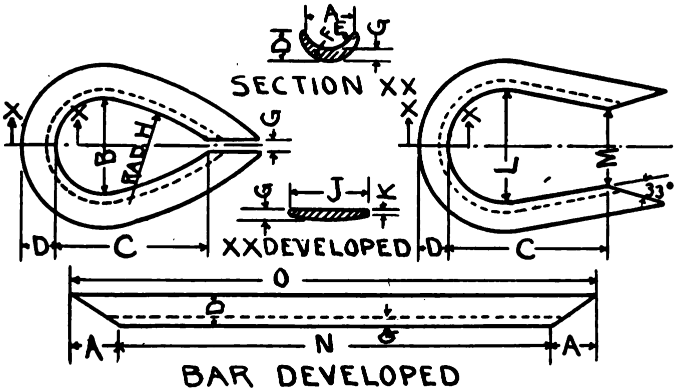


Dia. of Screw	A	B	C	D	E	F	Wt. Lbs.
7/8	1 1/2	7	1 5/8	1 7/8	1 1/8	1/4	3
1	1 1/2	7	1 5/8	1 7/8	1 1/8	1/4	3
1 1/8	1 3/4	7 1/2	2	2 5/16	1 3/8	5/16	4
1 1/4	1 3/4	7 1/2	2	2 5/16	1 3/8	5/16	4
1 3/8	2	8	2 3/8	2 3/4	1 5/8	3/8	5
1 1/2	2	8	2 3/8	2 3/4	1 5/8	3/8	6
1 5/8	2 1/4	8 1/2	2 3/4	3 3/16	1 7/8	7/16	8
1 3/4	2 1/4	8 1/2	2 3/4	3 3/16	1 7/8	7/16	9
1 7/8	2 1/2	9	3 1/8	3 5/8	2 1/8	1/2	10
2	2 1/2	9	3 1/8	3 5/8	2 1/8	1/2	11
2 1/8	2 3/4	9 1/2	3 1/2	4 1/16	2 3/8	9/16	14
2 1/4	2 3/4	9 1/2	3 1/2	4 1/16	2 3/8	9/16	15
2 3/8	3	10	3 7/8	4 1/2	2 5/8	5/8	18
2 1/2	3	10	3 7/8	4 1/2	2 5/8	5/8	19
2 3/4	3 1/4	10 1/2	4 1/4	4 15/16	2 7/8	11/16	23
2 7/8	3 1/2	11	4 5/8	5 3/8	3 1/8	3/4	27
3	3 1/2	11	4 5/8	5 3/8	3 1/8	3/4	28
3 1/4	3 3/4	11 1/2	5	5 13/16	3 3/8	13/16	35
3 1/2	4	12	5 3/8	6 1/4	3 5/8	7/8	40
3 3/4	4 1/4	12 1/2	5 3/4	6 11/16	3 7/8	15/16	47
4	4 1/2	13	6 1/8	7 1/16	4 1/8	1	55
4 1/4	4 3/4	13 1/2	6 1/2	7 1/2	4 3/8	1 1/16	65
4 1/2	5	14	6 7/8	7 15/16	4 3/4	1 1/16	75

[Pocket Companion—Carnegie Steel Co.]

Hexagon sleeve nuts largely used in tie rod connections.

ROPE THIMBLES



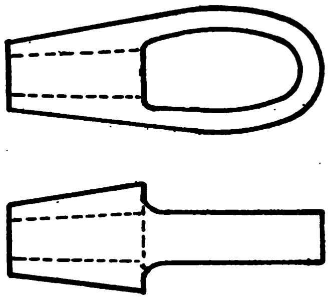
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Weight per 100
1/8	1/4	13/32	3/32	1/16	3/32	1/32	1	21/32	1/4	1/32	9/32	3/16	1 3/16	1 7/16	.3
3/16	3/8	39/64	1/8	3/32	9/64	3/64	1 1/2	15/16	11/32	3/64	27/64	9/32	1 3/4	2 1/8	.9
1/4	1/2	13/16	5/32	1/8	9/64	1/16	2	1 7/32	13/32	1/64	9/16	3/8	2 5/32	2 21/32	1.3
5/16	5/8	1 1/64	3/16	5/32	11/64	1/16	2 1/2	1 17/32	1/2	1/64	45/64	15/32	2 11/16	3 5/16	1.9
3/8	3/4	1 7/32	15/64	3/16	7/32	5/64	3	1 27/32	5/8	1/32	27/32	9/16	3 1/4	4	3.9
7/16	7/8	1 27/64	9/32	7/32	1/4	5/64	3 1/2	2 5/32	3/4	1/32	63/64	21/32	3 25/32	4 21/32	5.4
1/2	1	1 5/8	5/16	1/4	9/32	3/32	4	2 7/16	13/16	1/32	1 1/8	3/4	4 5/16	5 5/16	7.9
9/16	1 1/8	1 53/64	11/32	9/32	5/16	7/64	4 1/2	2 3/4	29/32	1/32	1 17/64	27/32	4 27/32	5 31/32	11.
5/8	1 1/4	2 1/32	25/64	5/16	11/32	1/8	5	3 1/16	1 1/32	1/32	1 13/32	15/16	5 3/8	6 5/8	16.
3/4	1 1/2	2 7/16	15/32	3/8	13/32	9/64	6	3 21/32	1 7/32	1/32	1 11/16	1 1/8	6 15/32	7 31/32	25.
7/8	1 3/4	2 27/32	35/61	7/16	15/32	5/32	7	4 1/4	1 7/16	1/32	1 31/32	1 5/16	7 9/16	9 5/16	38.
1	2	3 1/4	5/8	1/2	35/64	3/16	8	4 7/8	1 21/32	3/64	2 1/4	1 1/2	8 5/8	10 5/8	62.
1 1/8	2 1/4	3 71/32	45/64	9/16	39/61	7/32	9	5 1/2	1 15/16	3/64	2 17/32	1 11/16	9 11/16	11 15/16	94.
1 1/4	2 1/2	4 1/16	25/32	5/8	43/64	15/64	10	6 3/32	2 1/16	3/64	2 13/16	1 7/8	10 25/32	13 9/32	·118.
1 3/8	2 3/4	4 15/32	55/64	11/16	3/4	1/4	11	6 11/16	2 1/4	1/16	3 3/32	2 1/16	11 7/8	14 5/8	154.
1 1/2	3	4 7/8	15/16	3/4	13/16	9/32	12	7 5/16	2 1/2	1/16	3 3/8	2 1/4	12 15/16	15 15/16	208.
1 5/8	3 1/4	5 9/32	1 1/64	13/16	7/8	5/16	13	7 15/16	2 11/16	1/16	3 21/32	2 7/16	14	17 1/4	266.
1 3/4	3 1/2	5 11/16	1 3/32	7/8	61/64	1/64	14	8 17/32	2 7/8	5/64	3 15/16	2 5/8	15 3/32	18 19/32	327.
1 7/8	3 3/4	6 3/32	1 11/64	15/16	1 1/64	11/32	15	9 1/8	3 1/8	5/64	4 7/32	2 13/16	16 3/16	19 15/16	398.
2	4	6 1/2	1 1/4	1	1 3/32	3/8	16	9 3/4	3 5/16	3/32	4 1/2	3	17 1/4	21 1/4	495.
2 1/4	4 1/2	7 5/16	1 13/32	1 1/8	1 7/32	27/64	18	10 31/32	3 3/4	3/32	5 1/16	3 3/8	19 13/32	23 29/32	700.
2 1/2	5	8 1/8	1 9/16	1 1/4	1 25/64	15/32	20	12 3/16	4 1/8	7/64	5 5/8	3 3/4	21 9/16	26 9/16	960.
2 3/4	5 1/2	8 15/16	1 23/32	1 3/8	1 1/2	33/64	22	13 13/32	4 9/16	1/8	6 3/16	4 1/8	23 23/32	29 7/32	1290.
3	6	9 3/4	1 7/8	1 1/2	1 41/64	9/16	24	14 5/8	4 15/16	9/64	6 3/4	4 1/2	25 7/8	31 7/8	1670.

[Upson-Walton Co., Cleveland, O.]

Thimbles are usually galvanized.

WIRE ROPE SOCKETS

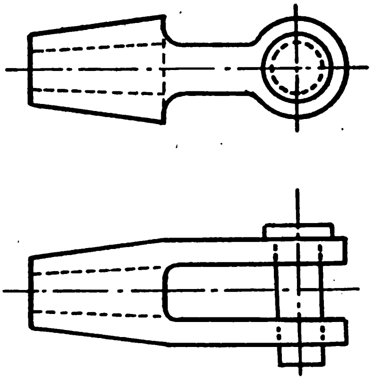
Closed



Size Rope Dia.	Extreme Length	Basket		
		Length	Large Diameter Outside	Small Diameter Outside
1/4	3 5/8	1 5/8	1 3/16	5/8
5/16	3 5/8	1 5/8	1 3/16	5/8
3/8	4 1/2	2	1 7/16	13/16
7/16	4 1/2	2	1 7/16	13/16
1/2	5 1/4	2 1/4	1 3/4	1
9/16	5 1/4	2 1/4	1 3/4	1
5/8	6 1/8	2 5/8	2	1 3/16
3/4	7	3	2 3/8	1 3/8
7/8	8	3 1/2	2 3/4	1 5/8
1	9 1/4	4	3 1/4	1 15/16
1 1/8	9 1/4	4	3 1/4	1 15/16
1 1/4	11 1/2	5	4	2 3/8
1 3/8	11 1/2	5	4	2 3/8
1 1/2	13	5 3/4	4 3/4	2 3/4
1 5/8	13	5 3/4	4 3/4	2 3/4

The socket should have a tapered hole or one as shown on page 207. The rope wires may be bent over, and lead or other soft metal poured in.

OPEN

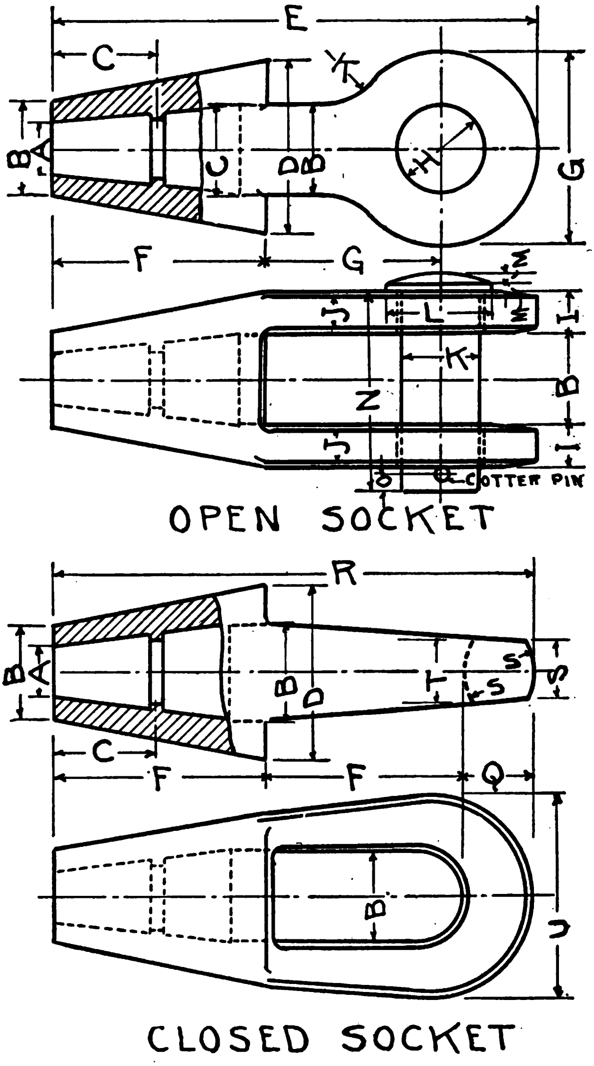


Size Rope Dia.	Extreme Length	Basket Length	Basket Large Diameter Outside	Basket Small Diameter Outside	Diameter Pin
1/4	3 7/16	1 5/8	1 3/16	5/8	1/2
5/16	3 7/16	1 5/8	1 3/16	5/8	1/2
3/8	4 3/8	2	1 7/16	13/16	5/8
7/16	4 3/8	2	1 7/16	13/16	5/8
1/2	5 1/8	2 1/4	1 3/4	1	3/4
9/16	5 1/8	2 1/4	1 3/4	1	3/4
5/8	6	2 5/8	2	1 3/16	7/8
3/4	6 7/8	3	2 3/8	1 3/8	1
7/8	7 7/8	3 1/2	2 3/4	1 5/8	1 1/4
1	9 1/8	4	3 1/4	1 15/16	1 1/2
1 1/8	9 1/8	4	3 1/4	1 15/16	1 1/2
1 1/4	11 3/8	5	4	2 3/8	1 7/8
1 3/8	11 3/8	5	4	2 3/8	1 7/8
1 1/2	13	5 3/4	4 3/4	2 3/4	2 1/4
1 5/8	13	5 3/4	4 3/4	2 3/4	2 1/4

[J. H. Williams Co., Brooklyn, N. Y.]

Pins have a 1/8 in. split pin in end close to shoulder.
For securing rope in socket see pages 205 and 207.

WIRE ROPE SOCKETS

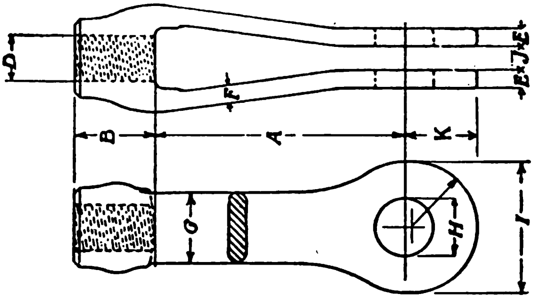


Wire Rope Sockets—*Continued*

Rope Dia.	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P *	Q	R	S	T	U	Weight, Lbs.	
																						Open with Pin	Cl's'd
1/4	9/32	5/8	3/4	1 1/8	3 3/8	1 1/2	1 1/4	17/32	1/4	3/16	1/2	11/16	1/8	1 7/16	3/16	1/8 x 1	1/2	3 1/2	3/8	7/16	1 3/8	.50	.37
5/16	11/32	11/16	13/16	1 1/4	3 11/16	1 5/8	1 3/8	19/32	9/32	3/16	9/16	3/4	1/8	1 9/16	3/16	1/8 x 1	17/32	3 25/32	13/32	15/32	1 1/2	.64	.47
3/8	13/32	3/4	7/8	1 3/8	4	1 3/4	1 1/2	21/32	5/16	7/32	5/8	13/16	5/32	1 13/16	9/32	3/16 x 1 1/4	9/16	4 1/16	7/16	1/2	1 5/8	.80	.59
7/16	15/32	13/16	15/16	1 1/2	4 5/16	1 7/8	1 5/8	23/32	11/32	7/32	11/16	7/8	5/32	1 15/16	9/32	3/16 x 1 1/4	19/32	4 11/32	15/32	17/32	1 3/4	.98	.72
1/2	17/32	7/8	1	1 5/8	4 5/8	2	1 3/4	13/16	3/8	1/4	3/4	15/16	5/32	2 1/16	9/32	3/16 x 1 1/2	5/8	4 5/8	1/2	9/16	1 7/8	1.2	.88
9/16	5/8	1	1 1/8	1 7/8	5 1/4	2 1/4	2	15/16	7/16	9/32	7/8	1 1/16	5/32	2 5/16	9/32	3/16 x 1 1/2	3/4	5 1/4	9/16	5/8	2 1/8	1.7	1.3
5/8	11/16	1 1/8	1 1/4	2 1/16	5 25/32	2 1/2	2 3/16	1 1/16	15/32	5/16	1	1 1/4	3/16	2 11/16	3/8	1/4 x 1 3/4	7/8	5 7/8	5/8	23/32	2 3/8	2.3	1.7
3/4	13/16	1 5/16	1 1/2	2 7/16	6 15/16	3	2 5/8	1 3/16	9/16	3/8	1 1/8	1 3/8	3/16	3 1/16	3/8	1/4 x 1 3/4	15/16	6 15/16	3/4	27/32	2 13/16	4.0	3.0
7/8	15/16	1 9/16	1 3/4	2 7/8	8 3/32	3 1/2	3 1/16	1 7/16	21/32	7/16	1 3/8	1 11/16	1/4	3 9/16	7/16	5/16 x 2 1/4	1 1/8	8 1/8	7/8	1	3 5/16	6.4	4.7
1	1 1/16	1 3/4	2	3 1/4	9 1/4	4	3 1/2	1 9/16	3/4	1/2	1 1/2	1 7/8	9/32	3 15/16	7/16	5/16 x 2 1/2	1 1/4	9 1/4	1	1 1/8	3 3/4	9.5	7.0
1 1/8	1 7/32	2	2 1/4	3 11/16	10 13/32	4 1/2	3 15/16	1 7/8	27/32	9/16	1 3/4	2 1/8	9/32	4 3/8	7/16	5/16 x 2 3/4	1 7/16	10 7/16	1 1/8	1 9/32	4 1/4	13.5	10.0
1 1/4	1 11/32	2 3/16	2 1/2	4 1/16	11 9/16	5	4 3/8	2	15/16	5/8	1 7/8	2 5/16	5/16	4 7/8	1/2	3/8 x 2 3/4	1 9/16	11 9/16	1 1/4	1 13/32	4 11/16	18.6	13.7
1 3/8	1 15/32	2 7/16	2 3/4	4 1/2	12 23/32	5 1/2	4 13/16	2 1/4	1 1/32	11/16	2 1/8	2 9/16	11/32	5 5/16	1/2	3/8 x 3	1 3/4	12 3/4	1 3/8	1 9/16	5 3/16	24.7	18.2
1 1/2	1 19/32	2 5/8	3	4 7/8	13 7/8	6	5 1/4	2 3/8	1 1/8	3/4	2 1/4	2 11/16	3/8	5 11/16	1/2	3/8 x 3 1/4	1 7/8	13 7/8	1 1/2	1 11/16	5 5/8	32.1	23.6
1 5/8	1 23/32	2 7/8	3 1/4	5 5/16	15 1/32	6 1/2	5 11/16	2 5/8	1 7/32	13/16	2 1/2	2 15/16	3/8	6 1/4	9/16	7/16 x 3 3/4	2 1/16	15 1/16	1 5/8	1 27/32	6 1/8	40.8	30.0
1 3/4	1 27/32	3 1/16	3 1/2	5 11/16	16 3/16	7	6 1/8	2 3/4	1 5/16	7/8	2 5/8	3 1/16	13/32	6 5/8	9/16	7/16 x 4	2 3/16	16 3/16	1 3/4	1 31/32	6 9/16	51	38
1 7/8	1 31/32	3 5/16	3 3/4	6 1/8	17 11/32	7 1/2	6 9/16	3	1 13/32	15/16	2 7/8	3 5/16	7/16	7 1/16	9/16	7/16 x 4	2 3/8	17 3/8	1 7/8	2 1/8	7 1/16	63	46
2	2 1/8	3 1/2	4	6 1/2	18 1/2	8	7	3 1/8	1 1/2	1	3	3 1/2	15/32	7 9/16	5/8	1/2 x 5	2 1/2	18 1/2	2	2 1/4	7 1/2	76	56
2 1/4	2 3/8	3 15/16	4 1/2	7 5/16	20 13/16	9	7 7/8	3 1/2	1 11/16	1 1/8	3 3/8	3 7/8	15/32	8 3/8	5/8	1/2 x 5	2 13/16	20 13/16	2 1/4	2 17/32	8 7/16	108	79
2 1/2	2 5/8	4 3/8	5	8 1/8	23 1/8	10	8 3/4	3 7/8	1 7/8	1 1/4	3 3/4	4 1/4	1/2	9 3/16	5/8	1/2 x 6	3 1/8	23 1/8	2 1/2	2 13/16	9 3/8	149	110

[Upson-Walton Co., Cleveland, O.]   * P = Cotter or Split Pin.

CLEVIS NUTS



Tap D	Diameter of Pin														
	3/4	7/8	1	1 1/4	1 1/2	1 3/4	2	2 1/4	2 1/2	2 3/4	3	3 1/4	3 1/2	3 3/4	4
1/2	2	2	2	...	...	...	...	Size of Eye Used with Wrought Iron Rods—50,000 Lbs. per Sq. In.							
5/8	2	2	2 1/2	2 1/2	2 1/2	...	...								
3/4	...	2 1/2	2 1/2	2 1/2	2 1/2	3	...								
7/8	...	...	2 1/2	2 1/2	3	3	...	...	...	...	...	...	...	...	...
1	...	...	3	3	3	3	3 1/2	...	...	...	...	...	...	...	...
1 1/8	...	...	...	3	3	3	3 1/2	3 1/2	...	...	...	...	...	...	...
1 1/4	...	...	...	3	3	3	3 1/2	3 1/2	...	...	...	...	...	...	...
1 3/8	...	...	...	3	3	3 1/2	3 1/2	4	4	...	...	...	...	...	...
1 1/2	...	...	...	...	3 1/2	3 1/2	4	4	4 3/4	...	...	...	...	...	...
1 5/8	...	...	...	...	4	4	4	4 3/4	4 3/4	4 3/4	...	...	...	...	...
1 3/4	...	...	...	...	...	4 3/4	4 3/4	4 3/4	4 3/4	4 3/4	...	...	...	...	...
1 7/8	...	...	...	...	...	...	4 3/4	4 3/4	4 3/4	5 3/4	5 3/4	...	...	...	...
2	...	...	...	...	...	...	4 3/4	4 3/4	5 3/4	5 3/4	5 3/4	...	...	...	...
2 1/8	...	...	...	...	...	...	...	5 3/4	5 3/4	5 3/4	5 3/4	5 3/4	...	...	...
2 1/4	...	...	...	...	...	...	...	5 3/4	5 3/4	5 3/4	5 3/4	6 3/4	6 3/4	...	...
2 3/8	...	...	...	...	...	...	...	5 3/4	5 3/4	5 3/4	6 3/4	6 3/4	6 3/4	6 3/4	...
2 1/2	...	...	...	...	...	...	...	...	6 3/4	6 3/4	6 3/4	6 3/4	6 3/4	6 3/4	...
2 5/8	...	...	...	...	...	...	...	...	6 3/4	6 3/4	6 3/4	6 3/4	6 3/4	8	8
2 3/4	...	...	...	...	...	...	...	...	...	6 3/4	6 3/4	6 3/4	8	8	8
3	...	...	...	...	...	...	...	...	...	...	8	8	8	8	8

For dimensions of nuts see page 210.

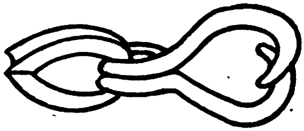
CLEVIS NUTS—*Continued*

I	B	A	K	G	F	E	J
2	1 1/4	5 1/2	1 1/8	1	3/8	3/8	To suit Pin Plate
2 1/2	1 3/8	5 1/2	1 7/16	1 1/4	7/16	15/32	
3	1 3/4	6	1 11/16	1 5/8	1/2	17/32	
3 1/2	2	6 1/2	1 15/16	1 7/8	9/16	19/32	
4	2 3/8	7	2 1/4	2 1/8	5/8	21/32	
4 3/4	2 3/4	8	2 5/8	2 1/2	23/32	25/32	
5 3/4	3 1/2	9	3 3/16	3	27/32	15/16	
6 3/4	4	10	3 7/8	3 1/4	15/16	1 1/16	
8	4 1/2	12	4 1/2	4	1 1/16	1 1/4	
9	4 3/4	12	5	4 1/2	1 5/16	1 1/2	

Dimension "E" will vary slightly, depending upon dimension "J."

[Cleveland City Forge & Iron Co., Cleveland, O.]

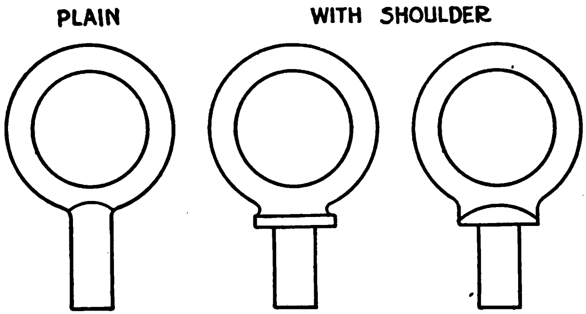
SISTER HOOKS WITH WIRE ROPE THIMBLE



Size of Iron, Inches	Size Score of Thimble, Inches	Length of Hook, Inches	Diameter of Eye, Inside Inches	Gov't Test. Maximum Strength in Pounds
1/4	3/16	2 1/8	9/16	940
5/16	1/4	2 3/8	5/8	1,420
3/8	5/16	2 7/8	11/16	2,030
1/2	7/16	3 1/2	7/8	3,800
5/8	1/2	4 1/8	1 1/16	7,100
3/4	5/8	5 1/8	1 3/16	8,920
7/8	3/4	5 3/4	1 1/4	11,020
1	7/8	6 3/8	1 3/8	11,100
1 1/8	1	6 1/2	1 5/8	13,050
1 1/4	1 1/8	7 1/4	1 3/4	19,200

For dimensions of thimbles see page 204.

EYE BOLTS

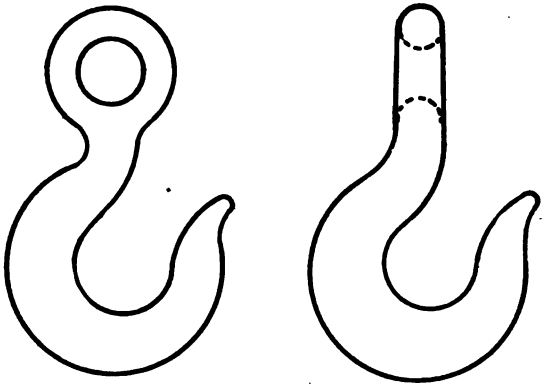


Shank		Maximum Length in Stock	Diameter Eye		Capacity, Net Tons		
Diam.	Standard Length under Shldr.		Inside	Outside	Safe Working Load	Average Load at Elastic Limit	Approximate Breaking Strain
1/4	1	3	3/4	1 3/16	.2	.5	1.5
5/16	1 1/8	4	7/8	1 7/16	.4	.9	2.
3/8	1 1/4	4 1/2	1	1 21/32	.7	1.4	3.
7/16	1 3/8	4 1/2	1 3/32	1 27/32	1.	2.	4.
1/2	1 1/2	4 1/2	1 3/16	2 1/16	1.3	2.5	5.
9/16	1 5/8	4 1/2	1 9/32	2 9/32	1.5	3.	6.
5/8	1 3/4	4 1/2	1 3/8	2 1/2	2.	4.	8.
3/4	2	5	1 1/2	2 13/16	3.	6.	12.
7/8	2 1/4	5	1 11/16	3 1/4	3.5	7.	16.
1	2 1/2	5	1 13/16	3 9/16	4.	8.	20.
1 1/8	2 3/4	5	2	4	5.	10.	23.
1 1/4	3	6	2 3/16	4 7/16	7.5	15.	33.
1 1/2	3 1/2	6	2 1/2	5 3/16	9.	18.	42.
1 3/4	3 3/4	6	2 7/8	6 1/16	11.	21.	53.
2	4	6	3 1/4	6 7/8	13.	25.	68.

[J. H. Williams Co., Brooklyn, N. Y.]

Plain eye with shank used for turnbuckle ends. Length of ends made to suit turnbuckle.

Hoist Hook

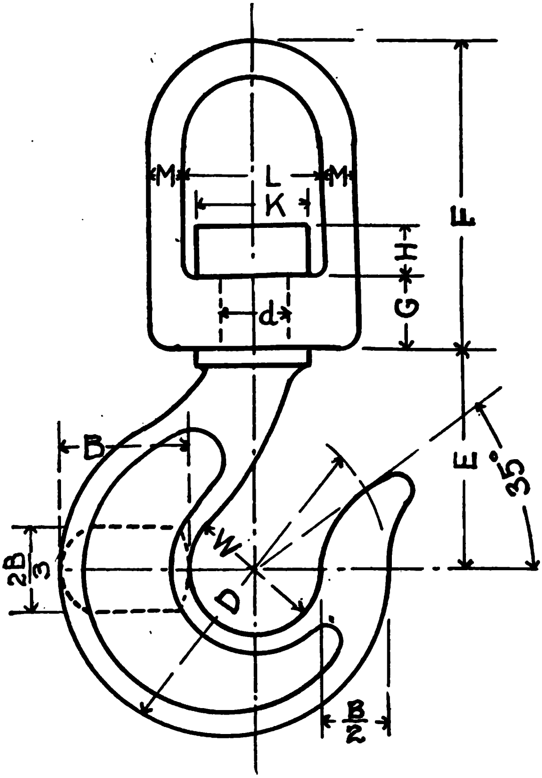


Diameter of Eye		Extreme Dimensions		Capacity, Net Tons		
Inside	Outside	Length	Width	Safe Working Load	Average Load at Elastic Limit	Approximate Load Required to Straighten out
3/4	1 1/2	4 3/8	2 7/8	.5	.9	1.9
7/8	1 3/4	4 7/8	3 1/8	.6	1.2	2.3
1	2	5 3/8	3 1/2	.7	1.5	3.
1 1/8	2 1/4	6 3/16	3 7/8	1.2	2.5	5.7
1 1/4	2 1/2	6 7/8	4 3/8	1.7	3.5	7.
1 3/8	2 3/4	7 5/8	4 7/8	2.1	4.2	8.5
1 1/2	3	8 9/16	5 5/8	2.5	5.4	10.
1 5/8	3 1/4	9 9/16	6 3/8	3.	6.2	13.
1 3/4	3 1/2	10 3/8	6 7/8	4.	8.	17.
2	4	11 1/2	7 1/2	4.7	9.	19.
2 3/8	4 5/8	13	8 1/4	5.5	11.	26.
2 3/4	5 1/4	14 3/4	9 1/4	6.8	13.	32.
3 1/8	6 1/8	16 3/4	10 7/8	8.	17.	35.
3 1/2	7	19 1/8	13	11.	21.	48.
4	8 1/2	22 1/2	14 3/4	20.	40.	80.

[J. H. Williams Co., Brooklyn, N. Y.]

Hook without eye, but with plain shank used for turnbuckle ends.

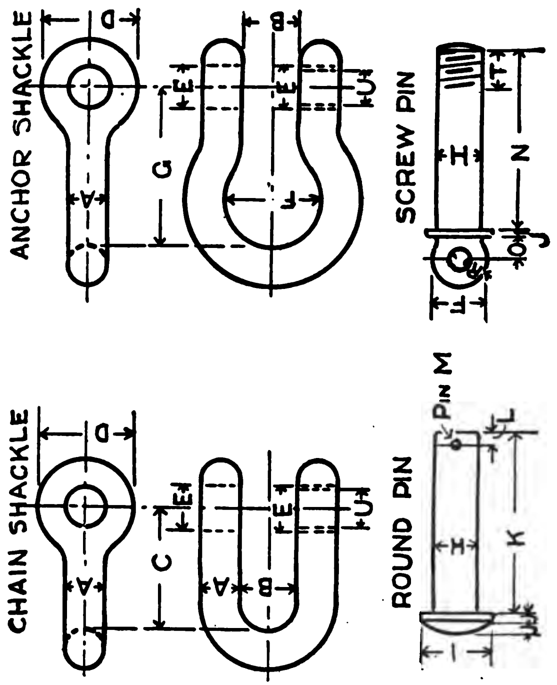
CRANE HOOK



Based upon a stress of 3,500 lbs. per sq. in., dia. d of shank of hook = .02 $\sqrt{\text{load.}}$ The width of the hook W = B the width of the hook body, the thickness being $\frac{2B}{3}$.

Diameter of hook circle D = B + 1.5 B

E = .5 B + .7 d	K = 1.7 d
F = 4.5 d	L = 2. d
G = 1.1 d	M = .7 d
H = .8 d	



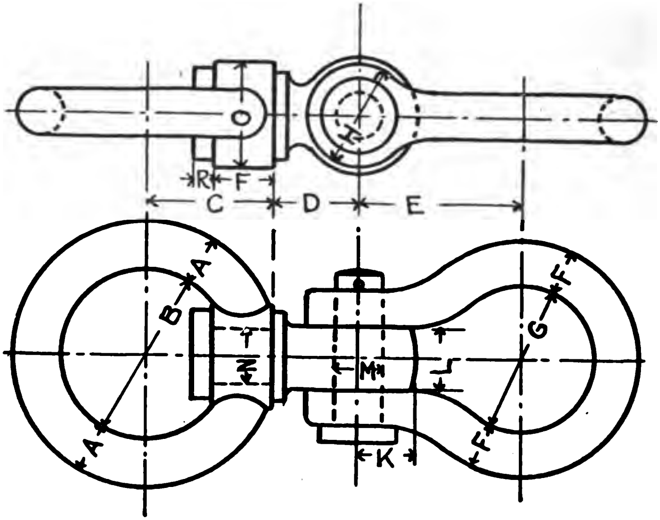
SHACKLES

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	*P	R	†S	T	U
3/16	5/16	5/8	5/8	9/32	1/2	3/4	1/4	3/8	1/16	15/16	5/32	3/32 x 1/2	11/16	3/16	3/8	1/8	20	1/4	13/64
1/4	3/8	13/16	3/4	11/32	5/8	1	5/16	1/2	3/32	1 1/8	5/32	3/32 x 3/4	7/8	1/4	1/2	5/32	18	5/16	1/4
5/16	1/2	1	7/8	13/32	13/16	1 1/4	3/8	9/16	3/32	1 3/8	5/32	3/32 x 3/4	1 1/8	9/32	9/16	3/16	16	3/8	5/16
3/8	9/16	1 1/4	1	1/2	15/16	1 1/2	7/16	5/8	1/8	1 5/8	3/16	1/8 x 1	1 5/16	5/16	5/8	7/32	14	7/16	23/64
7/16	11/16	1 7/16	1 1/8	9/16	1 1/8	1 3/4	1/2	11/16	1/8	1 7/8	3/16	1/8 x 1	1 9/16	11/32	11/16	7/32	13	1/2	27/64
1/2	3/4	1 5/8	1 1/4	5/8	1 1/4	2	9/16	3/4	1/8	2 1/16	3/16	1/8 x 1	1 3/4	3/8	3/4	1/4	12	9/16	15/32
9/16	7/8	1 13/16	1 3/8	23/32	1 7/16	2 1/4	5/8	13/16	5/32	2 7/16	9/32	3/16 x 1 1/4	2	13/32	13/16	9/32	11	5/8	17/32
5/8	15/16	2 1/16	1 5/8	27/32	1 9/16	2 1/2	3/4	15/16	5/32	2 5/8	9/32	3/16 x 1 1/4	2 3/16	15/32	15/16	5/16	10	3/4	41/64
3/4	1 1/8	2 7/16	1 7/8	31/32	1 7/8	3	7/8	1 1/16	5/32	3 1/16	9/32	3/16 x 1 1/2	2 5/8	17/32	1 1/16	11/32	9	7/8	49/64
7/8	1 5/16	2 7/8	2 1/8	1 3/32	2 3/16	3 1/2	1	1 1/4	3/16	3 11/16	3/8	1/4 x 1 3/4	3 1/16	5/8	1 1/4	13/32	8	1	7/8
1	1 1/2	3 1/4	2 3/8	1 7/32	2 1/2	4	1 1/8	1 3/8	3/16	4 1/8	3/8	1/4 x 1 3/4	3 1/2	11/16	1 3/8	15/32	7	1 1/8	63/64
1 1/8	1 11/16	3 5/8	2 5/8	1 3/8	2 13/16	4 1/2	1 1/4	1 1/2	7/32	4 9/16	3/8	1/4 x 2	3 15/16	3/4	1 1/2	1/2	7	1 1/4	1 7/64
1 1/4	1 7/8	4 1/16	2 7/8	1 1/2	3 1/8	5	1 3/8	1 3/4	1/4	5 1/16	7/16	5/16 x 2 1/4	4 3/8	27/32	1 11/16	9/16	6	1 3/8	1 7/32
1 3/8	2 1/16	4 7/16	3 1/8	1 5/8	3 7/16	5 1/2	1 1/2	1 7/8	9/32	5 1/2	7/16	5/16 x 2 1/2	4 13/16	15/16	1 7/8	5/8	6	1 1/2	1 11/32
1 1/2	2 1/4	4 7/8	3 5/8	1 7/8	3 3/4	6	1 3/4	2 1/16	9/32	5 15/16	7/16	5/16 x 2 3/4	5 1/4	1 1/32	2 1/16	11/16	5	1 5/8	1 35/64
1 5/8	2 7/16	5 1/4	3 7/8	2 1/32	4 1/16	6 1/2	1 7/8	2 5/16	5/16	6 1/2	1/2	3/8 x 2 3/4	5 11/16	1 5/32	2 5/16	25/32	5	1 3/4	1 43/64
1 3/4	2 5/8	5 11/16	4 1/8	2 5/32	4 3/8	7	2	2 7/16	11/32	6 15/16	1/2	3/8 x 3	6 1/8	1 7/32	2 7/16	13/16	4 1/2	1 7/8	1 25/32
2	3	6 1/2	4 5/8	2 13/32	5	8	2 1/4	2 3/4	3/8	7 13/16	1/2	3/8 x 3 1/4	7	1 3/8	2 3/4	29/32	4 1/2	2 1/8	2 1/32

[Upson-Walton Co., Cleveland, O.] * P = dia. of collar on screw pin. †S = threads per in.

Swivel Shackles

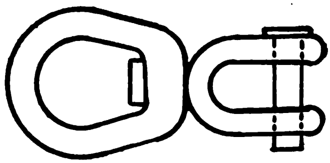
Stationary Chain Swivels



d = diameter of chain

A = 2 d	H = 4 d
B = 7 d	K = 2 d
C = 5 d	L = 2 d
D = 3 d	M = 2 d
E = 7 d	N = 2 d
F = 1.8 d	O = 4.3 d
G = 6 d	R = 1.5 d

Anchor Chain Swivels



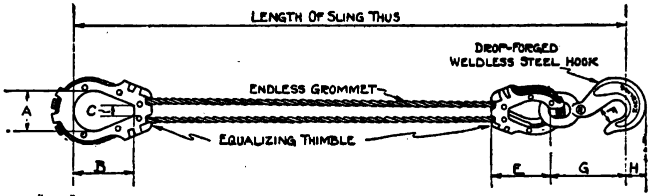
Diameter of metal in swivel = 1.8 d

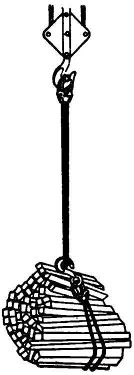
Inside diameter of swivel = 6 d
Inside length of swivel = 9 d
Thickness of swivel at shackle = 2 d
Swivel pin (N) dia. = 1.4 d
Dia. of metal in shackle = 1.4 d
For dimensions of shackles see pages 214 and 215.

In an anchor chain there should be three or four swivels, the first about five fathoms from the anchor.

WIRE ROPE SLINGS

Equalizing Slings with Hook
(Grommet Construction)

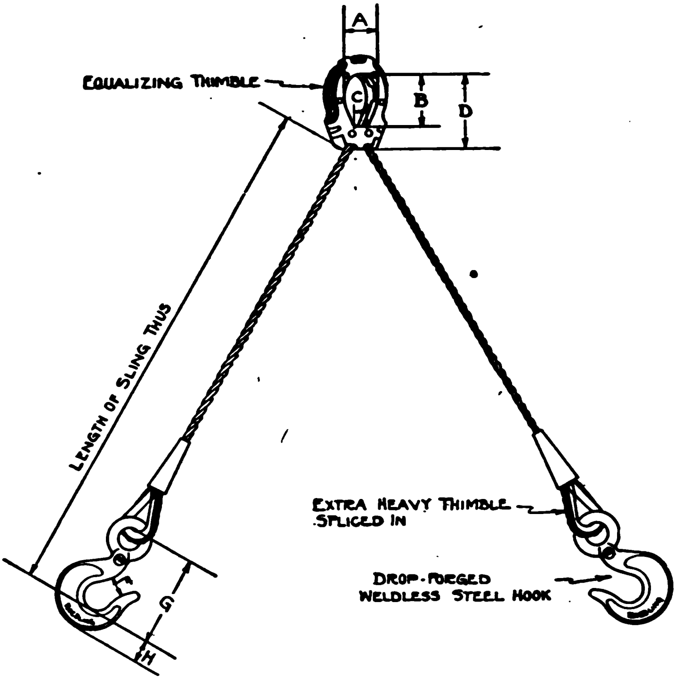




MAXIMUM SAFE LOADS, ETC.

DIAM. SLING	SAFE LOAD IN TONS OF 2,000 LBS.	HOOK			EQUALIZING THIMBLES									
						SET "M"			SET "L"			SET "SP"		
		F	G	H	E	A	B	C	A	B	C	A	B	C
1/2"	2	2 1/8"	8 7/16"	2 5/16"	7 1/16"	3 7/8"	5 1/2"	1 1/4"						
5/8	4	2 7/16	9 1/2	2 9/16	7 3/4	3 7/8	5 3/4	1 3/8						
3/4	6	2 9/16	10 5/16	2 3/4	7 3/4	3 7/8	5 3/4	1 3/8				8	12	1 7/8
7/8	8	3	11 11/16	3	8	5 1/4	8	1 1/4	6 5/8	10 1/4	1 15/16	8	12	1 7/8
1	10.5	3 3/4	13 5/8	3 1/2	8	5 1/4	8	1 1/4	6 5/8	10 1/4	1 15/16	8 1/2	13	2 1/16
1 1/8	13	4 1/2	15 1/2	4	9 1/8	5 1/4	7 3/4	1 1/2	7	10 5/8	2	8 1/2	13	2 1/16
1 1/4	15	5	18	4 3/4	9 1/8	5 1/4	7 3/4	1 1/2	7	10 5/8	2	8 1/2	13	2 1/8

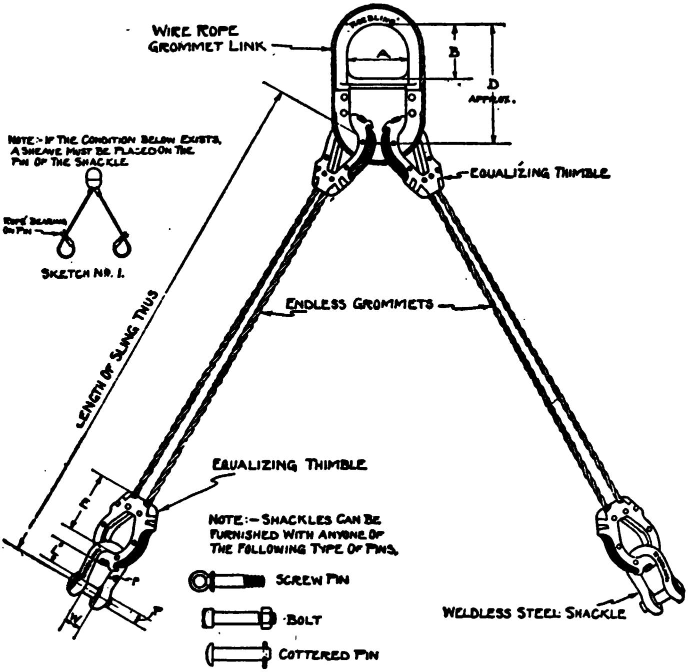
Equalizing Bridle Slings with Hooks



Dia. Sling	Safe Loads in tons of 2000 lbs. When Used Vertical	Safe Loads in tons of 2000 lbs. When Used 60° Angle	Hook F	Hook G	Hook H	Equalizing Thimbles Set "M" A	Set "M" B	Set "M" C	Set "M" D	Set "L" A	Set "L" B	Set "L" C	Set "L" D	Set "SP" A	Set "SP" B	Set "SP" C	Set "SP" D
½"	3	2.5	1½"	5 7/16"	1 9/16"	3⅛"	5½"	1¼"	7¾"								
⅝	4.5	4	1⅝	6 5/16	1¾	3½	5¾	1⅜	8⅜								
¾	6.25	5.5	1⅞	7½	2	3½	5¾	1⅜	8⅜					8"	12"	1⅞"	15"
⅞	9	8	2⅛	8 7/16	2 5/16	5¼	8	1¼	10¼	6½"	10¼"	1 13/16"	13"	8	12	1⅞	15
1	11.5	10	2 7/16	9½	2 9/16	5¼	8	1¼	10¼	6⅝	10¼	1 13/16	13	8½	13	1/16	16
1⅛	14	12	2 9/16	10 5/16	2¾	5¼	7¾	1½	10⅛	7	10⅝	2	13⅝	8½	13	2 1/16	16
1¼	17	14.5	3	11 11/16	3	5¼	7¾	1½	10½	7	10⅝	2	13⅝	8½	13	2⅛	16¼
1⅜	20	17	3 5/16	12 7/16	3⅛	6	9¾	1¾	13	8½	13	2½	16¼				
1½	23	20	3¾	13⅝	3½	6	9¾	1¾	13	8½	13	2½	16¼				
1⅝	25	22	4½	15½	4	9	14	2	17¾								
1¾	29	25	5	18	4¾	9¾	15	2½	19½								

[J. A. Roebling's Sons Co., Trenton, N. J.]

Shackle Bridle Slings



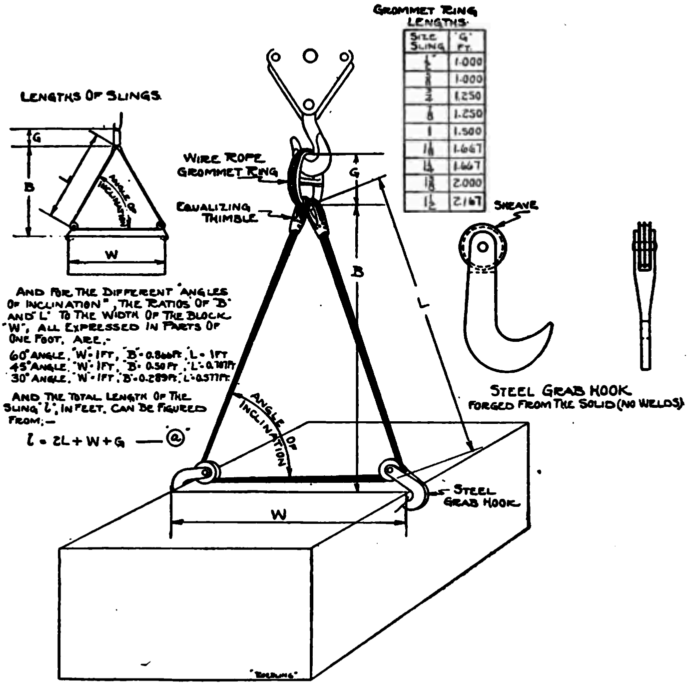
Dia. Sling	Safe Loads in Tons of 2,000 Lbs.				Fittings			
	When used Vertical	When used 60° Angle	When used 45° Angle	When used 30° Angle	A	B	D	E
½"	4	4	3	2	6"	6"	12"	7¾"
⅝	8	7	5.5	4	6	6	12	8⅜
¾	12	10	8.5	6	7½	7½	15	8⅜
⅞	16	13.5	11	8	7½	7½	15	8
1	21	18	15	10.5	9	9	18	8
1⅛	26	22	18.5	13	10	10	20	8½
1¼	30	26	21	15	10	10	20	8½
1⅜	34	29	24	17	12	12	24	11¼
1½	40	34	28	20	13	13	26	11¼
1⅝	44	38	31	22	13	13	26	11¼
1¾	50	43	35	25	14	15	30	19½

Note—Dimensions "F, L, P and W" of shackles are designed to suit the member hoisted. [J. A. Roebling's Sons Co., Trenton, N. J.]

Hook Bridle Slings

Same construction as Shackle Bridle Slings except hooks are used instead of shackles. For size of hooks see Equalizing Bridle Slings with Hooks.

Slings for Handling Stone Blocks



The wire rope grommet ring may be omitted, the equalizing thimbles being attached to the hook. In this case the length of the sling l = 2 L + W.

The sling shown is also suitable for handling steel plates.

SIZE OF SLINGS REQUIRED FOR DIFFERENT LOADS AND ANGLES OF INCLINATION

Weight of Block	Approximate Cubic Feet	Angle of Inclination		
		60°	45°	30°
4,000*	24	½"	½"	½"
8,000	48	½	⅝	⅝
10,000	60	⅝	⅝	¾
15,000	90	¾	¾	⅞
20,000	120	¾	⅞	1
25,000	150	⅞	1	1⅛
30,000	180	1	1	1¼
35,000	210	1	1⅛	1⅜
40,000	240	1⅛	1¼	1½
50,000	300	1¼	1½	

*Note—Above figured from—"Marble" at 165 lbs. per cu. ft.; "Granite" 3% heavier.

CHAINS

HOISTING CHAINS

The working load of a chain should not be above one fourth, and at most not over one third of its breaking strength, or but little over one half the proof test.

The distance from the center of one link to the center of the next is the pitch of the chain.

Chains for hoisting purposes should have short links in order to wrap snugly around the drum or sheave without bending.

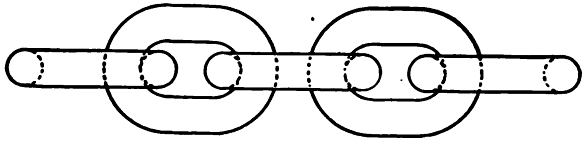
The life of a chain can be increased by frequent annealing and lubricating. If the wear is not uniform throughout the length, the chain should be cut and pieced where partially worn.

Chain having the trade name "B B B" crane chain, dimensions of which are given on page 222, is widely used not only for cranes but for general hoisting.

Drum scores for chain are given on pages 224–225.

Rings are made of heavier stock than the chain—see page 226.

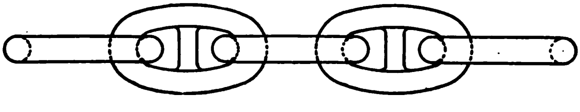
B. B. B. Crane Chain



Size Inches	Approximate Links per Foot	Outside Length Inches	Outside Width Inches	Weight per 100 Feet	Proof Test	Approximate Breaking Strain
3/16	15	1 1/8	3/4	52	1,200	2,400
1/4	14	1 3/8	15/16	83	1,750	4,500
5/16	12	1 5/8	1 1/8	118	3,400	7,000
3/8	11	1 7/8	1 7/16	175	4,500	9,000
7/16	10	2 1/8	1 9/16	215	6,300	12,500
1/2	9	2 3/8	1 3/4	275	8,000	16,500
9/16	8 1/4	2 3/4	2	340	10,000	22,000
5/8	7 1/2	3	2 1/8	435	12,500	25,000
3/4	5 3/4	3 1/2	2 9/16	620	17,750	35,000
7/8	5	4 1/16	3	830	24,000	47,500
1	4 3/4	4 5/8	3 1/2	1,040	31,350	64,500
1 1/8	4 1/2	5 1/8	3 7/8	1,400	38,000	78,000
1 1/4	4	5 3/4	4 1/4	1,665	47,000	95,000

[Columbus-McKinnon Chain Co., Columbus, O.]

Anchor Stud Link Cable Chain



Studs in chains keep the chains from closing when they are overstrained.

One shot of chain = 15 fathoms = 90 ft.

Ships built in the United States have anchor chain of the dimensions given on page 223.

(New American Measurements, adopted Aug. 21, 1917)

Size Chain Inches	Outside Length of Link Inches	Outside Width of Link Inches	Length of Six Links Outside Feet	In.	Average Weight Per Fathom Pounds	Proof Test Pounds	Breaking Strain Pounds
3/4	4 1/2	2 5/8	1	7 1/2	34	22,680	33,880
13/16	4 7/8	2 7/8	1	9 1/8	41	26,600	39,872
7/8	5 1/4	3 1/8	1	10 3/4	47	30,800	46,200
15/16	5 5/8	3 5/16	2	3/8	53	35,392	53,088
1	6	3 9/16	2	2	59	40,320	60,480
1 1/16	6 3/8	3 3/4	2	3 5/8	67	45,472	68,096
1 1/8	6 3/4	4	2	5 1/4	74	50,960	76,440
1 3/16	7 1/8	4 1/4	2	6 7/8	83	56,840	85,120
1 1/4	7 1/2	4 1/2	2	8 1/2	92	63,000	94,360
1 5/16	7 7/8	4 3/4	2	10 1/8	102	69,440	104,160
1 3/8	8 1/4	4 15/16	2	11 3/4	112	76,160	114,240
1 7/16	8 5/8	5 3/16	3	1 3/8	123	83,160	124,600
1 1/2	9	5 3/8	3	3	133	90,720	131,488
1 9/16	9 3/8	5 5/8	3	4 5/8	144	98,336	137,536
1 5/8	9 3/4	5 7/8	3	6 1/4	155	106,400	148,960
1 11/16	10 1/8	6 1/16	3	7 7/8	168	114,800	160,720
1 3/4	10 1/2	6 5/16	3	9 1/2	180	123,480	172,760
1 13/16	10 7/8	6 1/2	3	11 1/8	198	132,440	185,360
1 7/8	11 1/4	6 3/4	4	3/4	207	141,680	198,240
1 15/16	11 5/8	7	4	2 3/8	221	151,200	211,680
2	12	7 3/16	4	4	235	161,280	225,792
2 1/16	12 3/8	7 7/16	4	5 5/8	248	171,360	239,904
2 1/8	12 3/4	7 5/8	4	7 1/4	260	182,000	254,800
2 3/16	13 1/8	7 7/8	4	8 7/8	278	192,920	269,920
2 1/4	13 1/2	8 1/8	4	10 1/2	295	204,120	285,600
2 5/16	13 7/8	8 5/16	5	1/8	313	215,600	301,840
2 3/8	14 1/4	8 9/16	5	1 3/4	330	227,360	318,304
2 7/16	14 3/8	8 3/4	5	3 3/8	348	239,456	335,160
2 1/2	15	9	5	5	365	252,000	352,800
2 9/16	15 3/8	9 1/4	5	6 5/8	383	261,408	365,960
2 5/8	15 3/4	9 7/16	5	8 1/4	400	270,816	379,120
2 11/16	16 1/8	9 11/16	5	9 7/8	418	280,224	392,280
2 3/4	16 1/2	9 7/8	5	11 1/2	435	289,632	405,440
2 13/16	16 7/8	10 1/8	6	1 1/8	458	298,816	418,320
2 7/8	17 1/4	10 3/8	6	2 3/4	480	308,224	431,480
2 15/16	17 5/8	10 9/16	6	4 3/8	500	317,408	444,360
3	18	10 13/16	6	6	520	326,592	457,184
3 1/16	18 3/8	11	6	7 5/8	540	335,552	469,728
3 1/8	18 3/4	11 1/4	6	9 1/4	560	344,400	482,160
3 3/16	19 1/8	11 1/2	6	10 7/8	585	353,248	494,480
3 1/4	19 1/2	11 11/16	7	1/2	610	361,984	506,688

[Columbus-McKinnon Chain Co., Columbus, O.]

Chain Slings

The table shows safe working loads in pounds of special "CC" sling chains when operated at different angles. When handling molten metals, sling chains should be 25% stronger than in the table

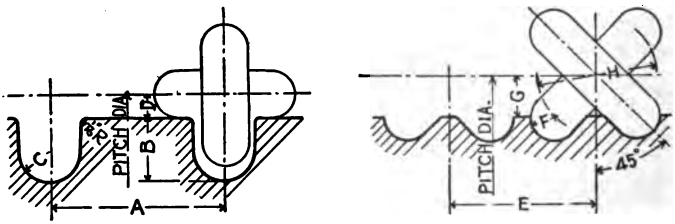
The safe working loads given are for each single strand. When used double or in other multiples, the loads may be increased proportionately.

	Diameter of Iron Inches	When Used Straight	When Used at 60-Degree Angle	When Used at 45-Degree Angle	When Used at 30-Degree Angle
"CC"	¼	1,330	1,000	850	600
Dredge	⅜	2,660	2,050	1,700	1,200
Chain	½	5,330	4,100	3,400	2,400
	⅝	8,330	6,800	5,600	4,000
(Best Grade of	¾	12,000	9,400	7,800	5,500
Hand-made,	⅞	16,330	12,800	10,400	7,400
Tested,	1	20,830	16,000	13,200	9,400
Short Link	1⅛	26,660	20,400	16,800	12,000
Chain.)	1¼	32,000	25,500	21,000	15,000
	1½	46,660	38,000	32,000	22,000

[Columbus-McKinnon Chain Co., Columbus, O.]

DRUM SCORES

For Chain

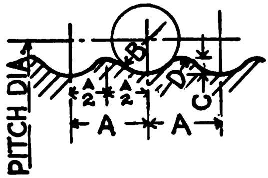


Drum Scores for Chain—*Continued*

Size of Chain	A	B	C	D	E	F	G	H
3/8	1 1/2	9/16	3/16	3/16	1 1/4	3/16	11/32	1
7/16	1 11/16	5/8	9/32	7/32	1 7/16	7/32	3/8	1 1/8
1/2	1 7/8	11/16	5/16	1/4	1 9/16	1/4	7/16	1 1/4
9/16	2 1/16	3/4	11/32	9/32	1 3/4	9/32	15/32	1 3/8
5/8	2 5/16	13/16	3/8	5/16	1 7/8	5/16	17/32	1 1/2
11/16	2 1/2	7/8	13/32	11/32	2 1/16	11/32	9/16	1 5/8
3/4	2 11/16	15/16	7/16	3/8	2 3/16	3/8	5/8	1 3/4
13/16	2 7/8	1	15/32	13/32	2 3/8	13/32	21/32	1 7/8
7/8	3 1/8	1 1/16	1/2	7/16	2 1/2	7/16	23/32	2
15/16	3 5/16	1 1/8	17/32	15/32	2 11/16	15/32	3/4	2 1/8
1	3 1/2	1 3/16	9/16	1/2	2 13/16	1/2	13/16	2 1/4

Chain drums and sheaves are usually made with a diameter of 20 to 25 times the thickness of the chain iron, the diameter being taken to the center of the chain.

For Rope



Dia. of Rope	A	B	C	D	Dia. of Rope	A	B	C	D
3/8	7/16	7/32	3/32	3/32	3/4	13/16		5/32	3/16
7/16	1/2	1/4	3/32	1/8	13/16	7/8		5/32	7/32
1/2	9/16	9/32	3/32	1/8	7/8	15/16	15/32	5/32	7/32
9/16	5/8	5/16	1/8	5/32	15/16	1	1/2	3/16	1/4
5/8	11/16	11/32	1/8	5/32	1	1 1/16	17/32	3/16	1/4
11/16	3/4	3/8	1/8	3/16	1 1/8	1 3/16	19/32	1/4	5/16

See also Pulley Grooves for Rope Transmission, pages 129 and 130.

HOOKS AND RINGS FOR CHAIN

Round slip hooks should be made from the best hammered iron three times the diameter of the material in the chain. Thus a slip hook for a ¾ inch chain should be of 2¼ inch stock.

Square grab hooks should be made from material twice the diameter of the chain. A grab hook for a ¾ inch chain, use 1½ stock.

Inside diameter of ring should be six times the diameter of the chain iron, and the ring stock twice the size of the chain. A ring for a ¾ inch chain should be made from 1½ inch material and be 4½ inches inside diameter.

TREATMENT OF STEEL

Annealing gives the steel a finer grain, and makes it more ductile. Steel castings and anchor chains are frequently annealed to increase their tensile strength and resistance to sudden shocks.

Hardening steel increases its tensile strength and elastic limit, but decreases its ductility. Steel is heated to a high temperature and then plunged into oil or water. Cutting tools for lathes, shapers, etc., are hardened.

Case hardening causes the steel to have a hard exterior surface and a soft interior. Gears and armor are case hardened.

Tempering is reheating hardened steel to restore a part of its ductility. Drills, metal working tools, etc., are tempered.

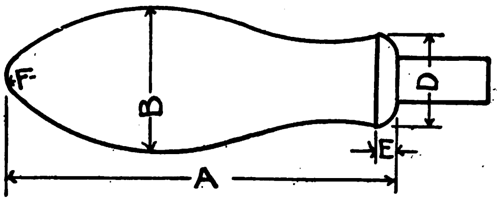
SECTION VI

MISCELLANEOUS DETAILS

HANDLES—HAND WHEELS—KNOBS—KNURLED SET—WRENCHES—STUFFING BOXES—DRILL SHANKS—WASHERS—CLINCH RINGS—SPRINGS — ANGLE COUPLINGS — KNUCKLE JOINTS — YOKE ENDS—ROD ENDS—TOOL STRAPS AND BOLTS—TAPER PINS — FINISHED ENDS OF SHAFTS, STUDS, SCREWS AND BUSHINGS—STANDARD SQUARES FOR CHUCK SCREWS AND WRENCHES

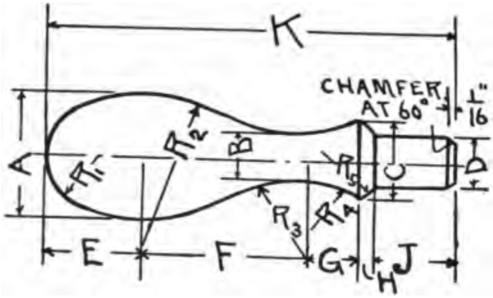
MACHINE HANDLES

CONE PATTERN



A	B	D	E	F	Dia. of Shank
2	3/4	7/16	1/8	1/8	5/16
2 1/2	1	9/16	5/32	5/32	3/8
3	1 1/8	5/8	3/16	3/16	1/2
3 1/4	1 3/16	3/4	3/16	1/4	5/8
3 1/2	1 5/16	7/8	1/4	5/16	11/16
3 3/4	1 3/8	1	1/4	3/8	3/4

Ball Pattern



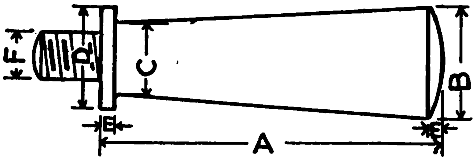
A	B	C	D	E	F	G	H	J	K	R_1	R_2	R_3	R_4	R_5
7/16	3/16	5/16	.252 .253	3/8	5/8	1/4	1/32	7/16	1 23/32	3/16	[illegible]/64	53/64	9/16	1/8
5/8	5/16	3/8	.252 .253	7/16	49/64	11/64	3/32	7/16	1 29/32	9/32	11/16	1 1/4	5/8	1/8
3/4	3/8	9/16	.3145 .3155	33/64	55/64	1/4	3/32	7/16	2 5/32	23/64	53/64	1 3/8	3/8	3/16
13/16	5/16	1/2	.3145 .3155	5/8	31/32	5/16	3/32	7/16	2 7/16	23/64	1 11/64	37/32	9/16	3/16
7/8	3/8	9/16	.377 .378	5/8	1 1/16	5/16	1/8	9/16	2 11/16	13/32	1 9/32	1 7/64	19/32	3/16
1	7/16	11/16	.4395 .4405	3/4	1 1/8	3/8	1/8	11/16	3 1/16	7/16	1 9/32	1 1/16	5/8	3/16
1 1/8	7/16	11/16	.4395 .4405	7/8	1 11/32	13/32	1/8	11/16	3 7/16	1/2	1 21/32	1 7/32	45/64	1/4
1 3/16	1/2	3/4	.4395 .4405	7/8	1 3/4	7/16	5/32	11/16	3 29/32	9/16	2 1/16	2 7/16	29/32	1/4
1 1/4	1/2	7/8	.503 .504	1	1 7/8	17/32	7/32	15/16	4 9/16	9/16	2 5/16	2 21/32	3/4	5/16
1 3/8	1/2	15/16	.503 .504	1	2 1/8	3/4	3/16	15/16	5	21/32	2 25/32	2 1/2	1 7/16	5/16
1 1/2	5/8	1 1/8	.628 .629	1 1/8	2 1/4	7/8	5/16	1 3/16	5 3/4	11/16	2 21/32	3 1/2	1 19/32	5/8

[Cincinnati Ball Crank Co., Cincinnati, O.]

Handles can be obtained with plain shanks that are riveted over, or with threaded shanks. The latter are preferable as it is not necessary to drill through the part the handle is to operate. Shanks of handles operating wheels or cranks turning right handed should have left hand threads to prevent unscrewing.

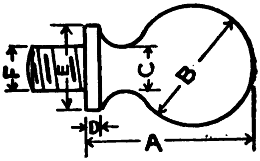
Handles are usually of drop forged steel, and are finished all over.

Tapered Sides



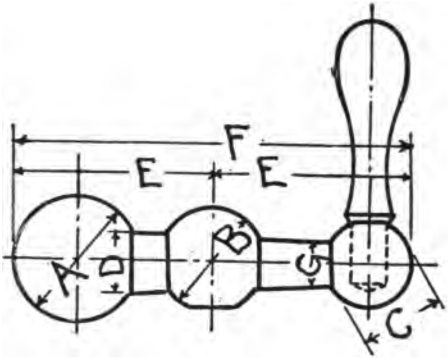
A	B	C	D	E	F
2½	¾	½	¾	3/32	⅜
3	1	⅝	⅞	⅛	7/16
3½	1⅛	11/16	1	5/32	½
4	1¼	1	1⅛	3/16	⅝

Spherical End



A	B	C	D	E	F
¾	⅝	¼	3/32	7/16	¼
1	¾	5/16	⅛	½	5/16
1⅜	1	⅜	⅛	11/16	⅜
1⅝	1¼	½	5/32	1	½
1¾	1⅜	¾	3/16	1⅛	⅝

Balanced Crank



A	B	C	D	E	F	G	Small Ball: Dia. of Hole	Small Ball: Depth of Hole
1	7/8	5/8	1/2	1 1/2	3	3/8	.25	1/2
1 1/8	1	3/4	1/2	1 3/4	3 1/2	3/8	.3125	9/16
1 1/4	1 1/8	13/16	9/16	2	4	7/16	.3125	9/16
1 3/8	1 1/4	15/16	9/16	2 1/4	4 1/2	7/16	.375	11/16
1 1/2	1 5/16	1	11/16	2 1/2	5	15/32	.4375	25/32
1 5/8	1 3/8	1	3/4	3	6	1/2	.4375	25/32
1 3/4	1 1/2	1 1/16	27/32	4	8	17/32	.4375	25/32
2	1 13/16	1 1/4	1	5 1/2	11	5/8	.5	1 1/32

[Cincinnati Ball Crank Co., Cincinnati, O.]

For handles see Machine Handles.

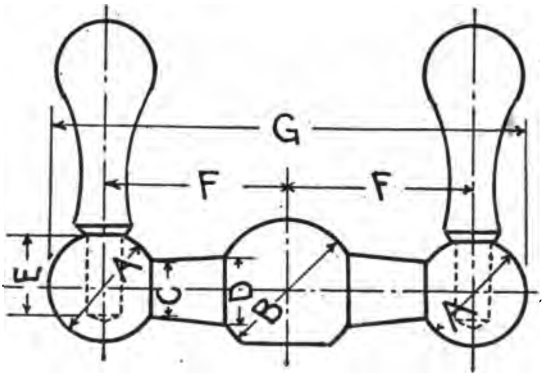
The center ball B may have a flat surface at the top as at the bottom.

The crank can be secured to the part it is to operate in a variety of ways. For instance, the ball B may have a square hole fitting over the end of the operated part, which is squared to suit and finished with a thread at the end. A nut is screwed onto the thread, thus holding the crank in place. Instead of a nut, the end may be riveted over.

Handles shown are screwed on, but by drilling through the balls and countersinking they can be riveted over.

Instead of the crank having a handle screwed or riveted into the ball C, the crank with handle can be made in one piece of drop forged steel.

COMPOUND REST



A	B	C	D	E	F	G
5/8	13/16	5/16	3/8	15/32	15/16	2 1/2
3/4	1 1/16	13/32	13/32	9/16	7/8	2 1/2
3/4	1 1/16	3/8	7/16	9/16	1 1/8	3
3/4	1 1/16	13/32	7/16	9/16	1 3/8	3 1/2
7/8	1 3/16	7/16	17/32	9/16	1 9/16	4
1 1/16	1 3/8	1/2	5/8	11/16	1 11/16	4 1/2
1 1/16	1 3/8	1/2	5/8	25/32	1 31/32	5

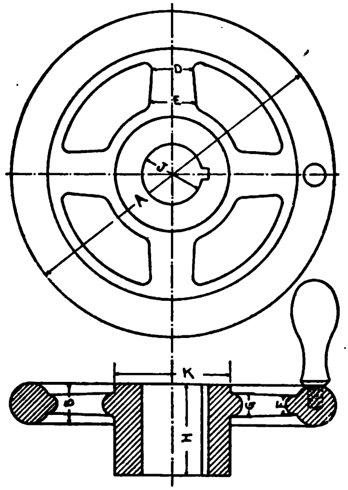
[Cincinnati Ball Crank Co., Cincinnati, O.]

For handles see Machine Handles.

Steel cranks and compound rests which come in contact with moisture should be lacquered to prevent rusting.

HANDWHEELS

Straight

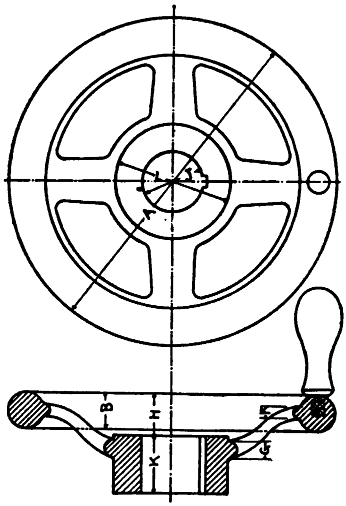


	Rim	Arm					Hub			
Diameter	Thickness	Width at Small End	Width at Large End	Thickness at Small End	Thickness at Large End	Number of Arms	Length	Bore	Dia.	Size of Keyway
A	B	D	E	F	G		H	J	K	
7	7/8	7/8	1	3/8	1/2	4	2 7/8	7/8	2 1/2	3/16 x 3/32
8	1	15/16	1 1/8	7/16	7/16	4	2	13/16	1 3/4	3/16 x 3/32
9	1 1/8	1	1 1/4	3/8	5/8	4	1 3/8	1 9/32	2 1/2	3/16 x 3/32
10	1 1/4	1	1 1/4	1/2	5/8	4	3 1/2	1 1/4	2 1/2	1/4 x 1/8
12	1 1/2	1 3/8	1 3/4	5/8	7/8	4	1 1/2	1 1/2	2 3/4	1/4 x 1/8
14	1 1/2	1 1/2	1 3/4	5/8	7/8	4	2 3/4	1 1/2	2 3/4	3/8 x 3/16
16	1 1/2	1 1/2	1 3/4	5/8	7/8	6	2 1/4	1 3/8	3	1/4 x 1/8
18	1 5/8	1 5/8	1 7/8	3/4	1	6	3 3/4	1 3/8	3 1/2	3/8 x 3/16
20	1 5/8	1 1/2	2	3/4	1	6	2	1 9/16	4 1/2	1/4 x 1/8
24	1 3/4	1 3/4	2 1/4	3/4	1	6	3 1/8	1 3/4	3 7/8	1/2 x 1/4

[Niles-Bement-Pond Co., New York.]

For handles see Machine Handles.

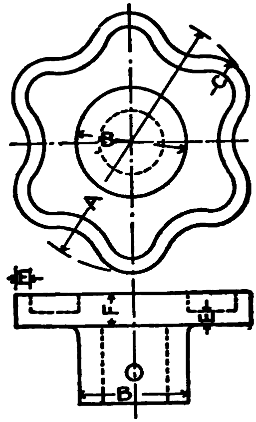
Dished



Diameter	Rim	Arm					Hub				
Diameter	Thickness	Width at Small End	Width at Large End	Thickness at Small End	Thickness at Large End	Number of Arms	Dish to Hub Face	Bore	Length	Diameter	Size of Keyway
A	B			F	G		H	J	K	L	
9	1⅛	1	1¼	⅜	⅝	4	9/16	1¼	2	2½	¼ x ⅛
10	1¼	1	1¼	⅜	⅝	4	1	1¼	2	2½	¼ x ⅛
12	1½	1⅛	1¾	⅜	⅞	4	1¾	⅞	1½	2	¼ x ⅛
13	1½	1¼	1¾	½	¾	4	2	1⅞	1½	2½	¼ x ⅛
14½	1½	1¼	1¾	½	¾	4	1¾	2	3	3	¼ x ⅛
18	1½	1½	1⅞	⅝	1	5	2⅛	1⅞	2⅝	3½	½ x ¼
20	1⅝	1⅜	1¾	¾	1	6	2⅛	1¾	3¼	3¾	⅜ x 3/16
20	1⅝	1⅜	1¾	¾	1	6	2⅛	2	5⅜	3¾	⅜ x 3/16
20	1⅝			¾	1	6	2⅛	2	2¼	3¾	⅜ x 3/16
20	1⅝	1⅜	1¾	¾	1	6	2⅛	2	9	3¾	⅜ x 3/16

[Niles-Bement-Pond Co., New York.]

Star



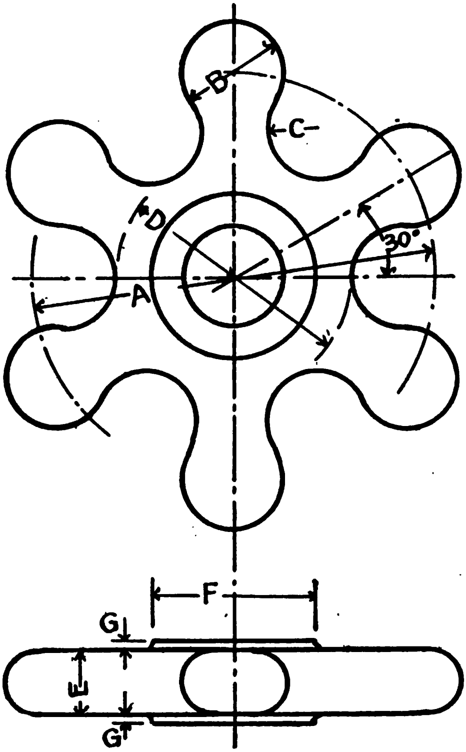
A	B	C	E	F	
2	7/8	5/16	1/8	5/16	Depth of hub to suit work
2½	1	3/8	1/8	5/16	
3	1¼	7/16	5/32	3/8	
3½	1⅜	7/16	3/16	7/16	
4	1½	1/2	3/16	1/2	
5	1⅝	5/8	1/4	5/8	

This wheel is usually of cast iron, and can be connected to the part it is to operate by a cylindrical, square or hexagonal projection to which it is pinned.

The dimension B is dependent on the size of the projection on which the star wheel is to be fitted.

No finish is generally required.

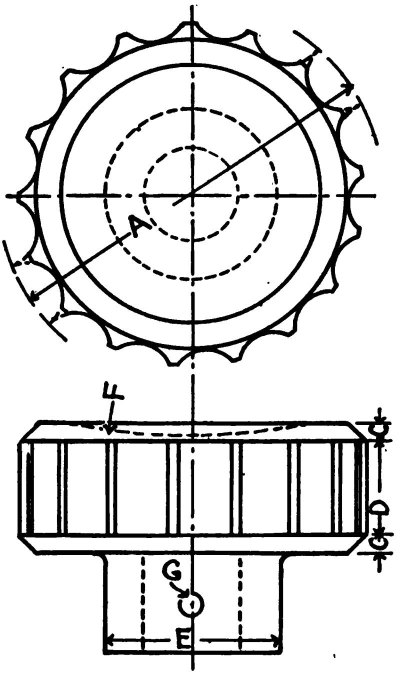
CAPSTAN



A	B	C	D	E	F	G
2½ 3 3½	⅝ ¾ 15/16	5/16 ⅜ 15/32	1¼ 1¾ 2	⅜ ½ 9/16	1¼ 1½ 1¾	1/16 1/16 3/32

May be keyed on, or fitted on the squared end of operated part.

KNOBS



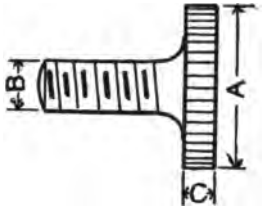
dia. of rod = d
A = 4 d
C = .2 d
D = d
Length of hub to suit work.

E = 1.8 d
Radius F = 6 d
Pin G, 1/8″ dia. for rods 3/16″ to 1/2″
1/4″ dia. for rods 7/16″ to 1″

To obtain the flutings on the side, divide the circumference of the circle having a diameter equal to 4d into any number of divisions, arbitrarily selected in the present case as 18, and describe arcs which are tangent to each other at the circumference of the circle. As the half circles spaced around will leave sharp points, cut them back so there is a flat face of 1/16″ or 3/32″.

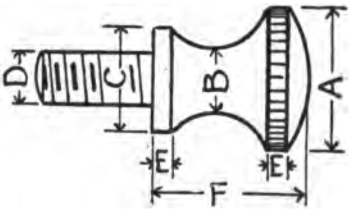
KNURLED SETS

Plain Knurled Set



A	B	C
3/4	3/16	1/8
7/8	1/4	5/32
1 1/8	5/16	3/16
1 1/4	3/8	1/4

Shoulder Single Knurled

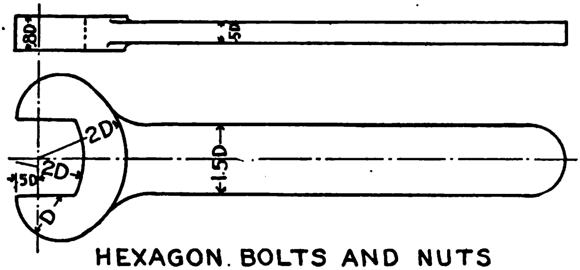


A	B	C	D	E	F
5/8	5/16	3/8	3/16	3/32	3/4
3/4	3/8	1/2	1/4	1/8	7/8
7/8	7/16	5/8	5/16	1/8	15/16
1	1/2	3/4	3/8	5/32	1 1/16

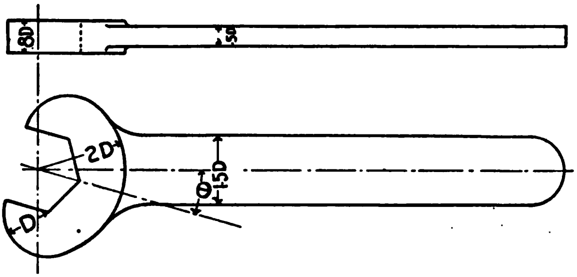
WRENCHES FOR BOLTS AND NUTS

Open Wrench

SQUARE BOLTS AND NUTS



HEXAGON. BOLTS AND NUTS

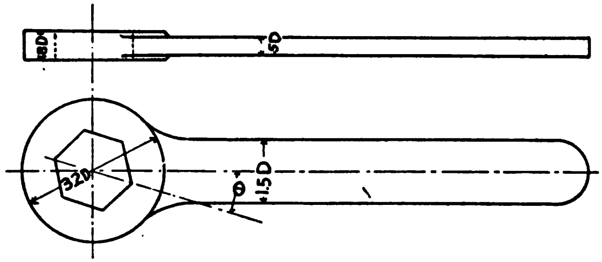


D = dia. of bolt
Angle θ = 0 degs. for machine tool wrenches
= 15 degs. for engineer's wrenches
= 22½ degs. for textile machines
Length of wrench = 12 to 16 D.

Finishes

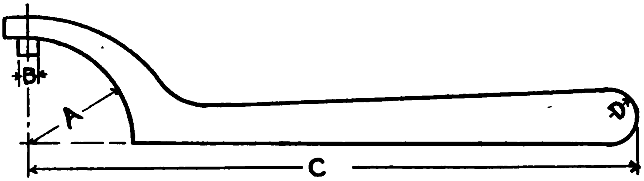
Unfinished or rough—opening milled, otherwise rough.
Semifinished—opening milled, head brightened and case hardened.
Finished—opening milled, case hardened and polished all over.

Box Wrench



For D, θ and length see Open Wrench.

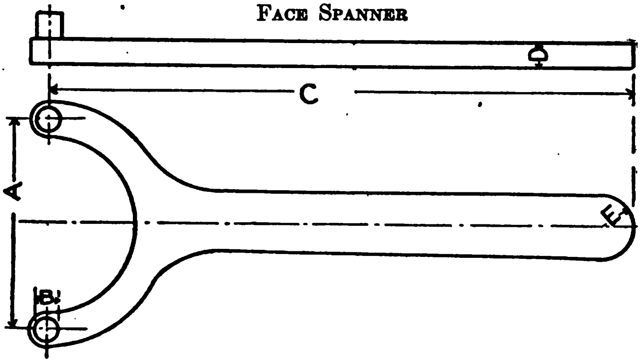
Spanner Wrench



A	B	C	D	Thickness
3/4	7/32	5	3/16	1/4
7/8	15/64	5 1/2	3/16	1/4
1	1/4	6	1/4	5/16
1 1/8	17/64	6 1/2	5/16	3/8
1 1/4	9/32	7	3/8	7/16
1 1/2	19/64	7 1/2	7/16	7/16
1 5/8	5/16	8	1/2	1/2
1 3/4	21/64	8 1/2	9/16	1/2

The diameter of the holes in the operated part should be 1/64 in. greater than the diameter of the pin B.

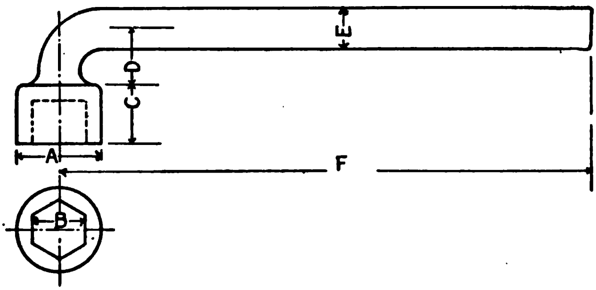
Face Spanner



A	B	C	D	E	A	B	C	D	E
1	3/16	4 1/2	1/4	1/4	2 1/4	1/4	6 3/8	3/8	3/8
1 1/4	7/32	5	1/4	1/4	2 1/2	9/32	6 3/4	7/16	3/8
1 1/2	7/32	5 3/8	1/4	5/16	2 3/4	9/32	7	1/2	1/2
1 3/4	7/32	5 3/4	1/4	5/16	3	5/16	7 3/8	1/2	1/2
2	1/4	6	5/16	5/16					

For diameter of hole, see note, page 239.

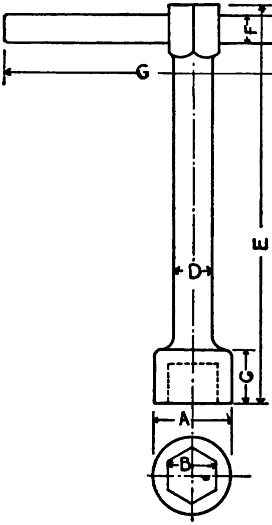
Offset Handle Socket Wrench



U. S. Standard Bolt Dia.	A	B	C	D	E	F
3/8	1 1/8	45/64	11/16	11/16	1/2	6 1/2
1/2	1 1/4	57/64	7/8	7/8	5/8	7 3/4
5/8	1 5/8	1 5/64	7/8	7/8	3/4	9
3/4	1 7/8	1 9/32	1	1	7/8	10
7/8	2 1/8	1 15/32	1 1/8	1 1/8	1	10 3/4
1	2 1/2	1 21/32	1 1/4	1 1/4	1 1/8	11 1/4
1 1/8	2 1/2	1 27/32	1 3/8	1 3/8	1 1/8	11 1/2
1 1/4	2 3/4	2 1/32	1 1/2	1 1/2	1 3/16	12

pth of hole in wrench should be 1/16 in. less than thickness of nut.

T Handle Socket Wrench

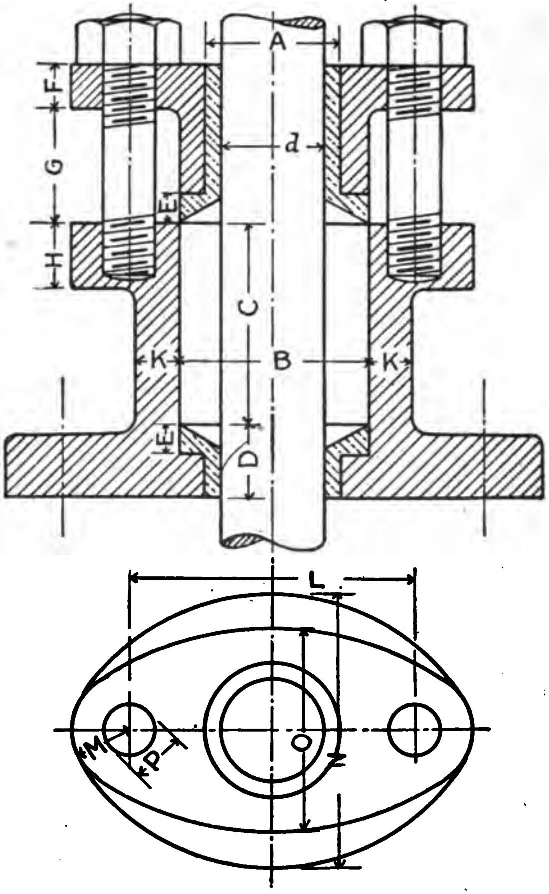


U. S. Standard Bolt Dia.	A	B	C	D	E	F	G
$\frac{1}{4}$	$\frac{3}{4}$	$\frac{33}{64}$	$\frac{9}{16}$	$\frac{3}{8}$	$5\frac{1}{4}$	$\frac{1}{4}$	$4\frac{1}{2}$
$\frac{5}{16}$	$\frac{7}{8}$	$\frac{39}{64}$	$\frac{5}{8}$	$\frac{7}{16}$	$5\frac{1}{2}$	$\frac{5}{16}$	$4\frac{7}{8}$
$\frac{3}{8}$	$1\frac{1}{8}$	$\frac{45}{64}$	$\frac{11}{16}$	$\frac{1}{2}$	$5\frac{3}{4}$	$\frac{3}{8}$	5
$\frac{7}{16}$	$1\frac{3}{16}$	$\frac{51}{64}$	$\frac{3}{4}$	$\frac{9}{16}$	6	$\frac{7}{16}$	$5\frac{1}{2}$
$\frac{1}{2}$	$1\frac{1}{4}$	$\frac{57}{64}$	$\frac{7}{8}$	$\frac{5}{8}$	$6\frac{1}{2}$	$\frac{1}{2}$	6
$\frac{9}{16}$	$1\frac{1}{2}$	$\frac{63}{64}$	$\frac{7}{8}$	$\frac{11}{16}$	$7\frac{1}{2}$	$\frac{9}{16}$	7
$\frac{5}{8}$	$1\frac{5}{8}$	$1\frac{5}{64}$	$\frac{7}{8}$	$\frac{3}{4}$	$8\frac{1}{2}$	$\frac{5}{8}$	8
$\frac{3}{4}$	$1\frac{7}{8}$	$1\frac{9}{32}$	1	$\frac{7}{8}$	$9\frac{1}{4}$	$\frac{5}{8}$	$8\frac{3}{4}$
$\frac{7}{8}$	$2\frac{1}{8}$	$1\frac{15}{32}$	$1\frac{1}{8}$	1	$10\frac{1}{4}$	$\frac{3}{4}$	$9\frac{1}{4}$
1	$2\frac{1}{2}$	$1\frac{21}{32}$	$1\frac{1}{4}$	$1\frac{1}{8}$	$10\frac{3}{4}$	$\frac{7}{8}$	$9\frac{1}{2}$
$1\frac{1}{8}$	$2\frac{1}{2}$	$1\frac{27}{32}$	$1\frac{3}{8}$	$1\frac{1}{8}$	$10\frac{3}{4}$	$\frac{7}{8}$	$9\frac{1}{2}$
$1\frac{1}{4}$	$2\frac{3}{4}$	$2\frac{1}{32}$	$1\frac{1}{2}$	$1\frac{3}{16}$	$11\frac{1}{4}$	1	10
$1\frac{3}{8}$	$3\frac{5}{16}$	$2\frac{7}{32}$	$1\frac{11}{16}$	$1\frac{3}{8}$	$12\frac{1}{4}$	$1\frac{1}{16}$	11
$1\frac{1}{2}$	$3\frac{5}{16}$	$2\frac{13}{32}$	$1\frac{13}{16}$	$1\frac{3}{8}$	$12\frac{1}{4}$	$1\frac{1}{16}$	11

Hexagon head for pin same size as bolt head. For depth of hole, see note, page 240.

STUFFING BOXES

Bolted Flange Type



d = dia. of rod

A = 1.31 d	H = .63 d
B = 1.8 d	K = .44 d
C = 2. d	L = 2.8 d
D = .7 d	M = .56 d
E = .31 d	N = 2.75 d
F = .44 d	O = 2. d
G = 1.13 d	

For rods	½″	to	1¹⁄₁₆″	dia. of stud P	= ⅜″
" "	¾″	"	1¼″	" " " "	= ½″
" "	1⅜″	"	1⅝″	" " " "	= ⅝″
" "	1¾″	"	2⅛″	" " " "	= ¾″
" "	2¼″	"	2½″	" " " "	= ⅞″

The top gland may be of composition instead of cast iron lined with composition. For large rods the gland in contact with the rod is reduced in length to cut down friction.

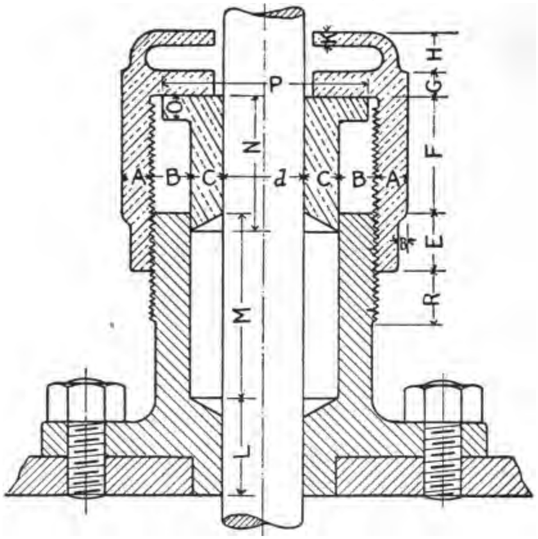
Studs of steel or bronze with steel nuts. Bronze studs with steel or composition nuts should be fitted where there is excessive moisture. Hole in gland for stud ¹⁄₁₆ in. larger than stud.

The part K may be cast on the engine cylinder or on the valve body, thus doing away with bolts.

It is important that the gland stud nuts be equally tightened so the pressure on the rod is the same at all points in its circumference. If the rod is well oiled the friction may be considerably reduced.

For low steam pressures hemp and cotton packings are suitable, but for high, metallic should be used.

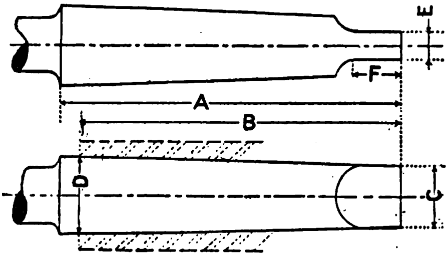
Screw Type



d = dia. of rod	
A = .34 d	L = 1.5 d
B = .52 d	M = 2. d
C = .43 d	N = 2.37 d
E = .75 d	O = .31 d
F = 1.4 d	P = 2.62 d
G = .31 d	R = d
H = .5 d	Gland of composition
K = .15 d	

The screw type is for smaller rods than the bolted flange and also for installations where the studs would be in the way. The gland is screwed down by using a wrench on the part A, which can be made with 6 or 8 notches or ribs in its circumference.

TAPERED DRILL SHANKS



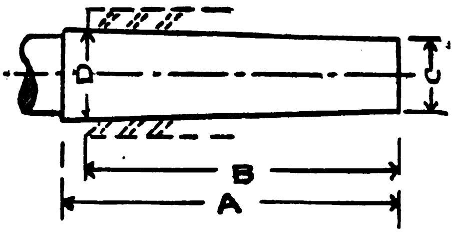
Morse Twist Drill & Mach. Co.

No.	A	B	C	D	E	F	Taper in 12-Inch
0	2 11/32	2 7/32	.240	.356	5/32	9/32	.625
1	2 9/16	2 3/8	.356	.475	13/64	3/8	.600
2	3 1/16	2 7/8	.556	.700	1/4	7/16	.602
3	3 3/4	3 9/16	.759	.938	5/16	9/16	.602
4	4 3/4	4 1/2	.997	1.231	15/32	5/8	.623
5	6	5 3/4	1.446	1.748	5/8	3/4	.630
6	8 5/16	8	2.077	2.494	3/4	1 1/8	.626

Brown & Sharpe

No.	A	B	C	D	E	F	Taper in 12-Inch
4	1 3/4	1 21/32	.333	.402	7/32	11/32	.500
5	2 9/32	2 3/16	.432	.523	1/4	3/8	.500
6	2 31/32	2 7/8	.479	.599	9/32	7/16	.500
6	3 27/32	3 3/4	.479	.635	9/32	7/16	.500
7	3 5/8	3 17/32	.578	.725	5/16	15/32	.500
7	4 5/8	4 17/32	.578	.767	5/16	15/32	.500
8	4 1/4	4 1/8	.727	.898	11/32	1/2	.500
9	4 3/4	4 5/8	.874	1.067	3/8	9/16	.500
9	5	4 7/8	.874	1.077	3/8	9/16	.500
10	6 1/16	5 23/32	1.022	1.260	7/16	21/32	.5161
10	6 3/4	6 13/32	1.022	1.289	7/16	21/32	.5161
10	7 9/32	6 15/16	1.022	1.312	7/16	21/32	.5161
11	7 13/16	7 15/32	1.220	1.531	7/16	21/32	.500
12	8 9/32	7 15/16	1.466	1.797	1/2	3/4	.500

JARNO



$$D = \text{Dia. of large end} = \frac{\text{No. of taper}}{8}$$

$$C = \text{Dia. of small end} = \frac{\text{No. of taper}}{10}$$

$$B = \text{Length of taper} = \frac{\text{No. of taper}}{2}$$

No.	A	B	C	D	Taper in 12 Inches
2	1⅛	1	.20	.250	.600
3	1⅝	1½	.30	.375	.600
4	2 3/16	2	.40	.500	.600
5	2 11/16	2½	.50	.625	.600
6	3 3/16	3	.60	.750	.600
7	3 11/16	3½	.70	.875	.600
8	4 3/16	4	.80	1.000	.600
9	4 11/16	4½	.90	1.125	.600
10	5¼	5	1.00	1.250	.600
11	5¾	5½	1.10	1.375	.600
12	6¼	6	1.20	1.500	.600
13	6¾	6½	1.30	1.625	.600
14	7¼	7	1.40	1.750	.600
15	7¾	7½	1.50	1.875	.600
16	8 5/16	8	1.60	2.000	.600
17	8 13/16	8½	1.70	2.125	.600
18	9 5/16	9	1.80	2.250	.600
19	9 13/16	9½	1.90	2.375	.600
20	10 5/16	10	2.00	2.500	.600

WASHERS

Circular Plate in Effect Jan. 20, 1910

U. S. Standard

Diameter	Size of Hole	Thickness		Size of Bolt	Number in 100 Lbs.
		Wire Gauge	Ins.		
9/16	1/4	18	.05	3/16	39,400
3/4	5/16	16	.06	1/4	15,600
7/8	3/8	16	.06	5/16	11,250
1	7/16	14	.08	3/8	6,800
1 1/4	1/2	14	.08	7/16	4,300
1 3/8	9/16	12	.11	1/2	2,600
1 1/2	5/8	12	.11	9/16	2,250
1 3/4	11/16	10	.14	5/8	1,300
2	13/16	9	.16	3/4	900
2 1/4	15/16	8	.17	7/8	782
2 1/2	1 1/16	8	.17	1	568
2 3/4	1 1/4	8	.17	1 1/8	473
3	1 3/8	8	.17	1 1/4	364
3 1/4	1 1/2	7	.18	1 3/8	275
3 1/2	1 5/8	7	.18	1 1/2	256
3 3/4	1 3/4	7	.18	1 5/8	220
4	1 7/8	7	.18	1 3/4	197
4 1/4	2	7	.18	1 7/8	174
4 1/2	2 1/8	7	.18	2	160

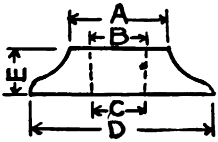
Square Plate

Inches Square	Size of Hole, Inches	Thickness, Inches	Thickness Decimal Parts of an Inch	Size of Bolt, Inches	Average Number in 100 Lbs.
1 1/2	7/16	1/8	.125	3/8	1,300
1 3/4	1/2	1/8	.125	7/16	1,100
2	9/16	3/16	.1875	1/2	500
2 1/4	23/32	1/4	.25	5/8	315
2 1/2	27/32	1/4	.25	3/4	250
3	31/32	1/4	.25	7/8	165
3 1/2	1 3/32	3/8	.375	1	87
4	1 1/4	3/8	.375	1 1/8	65
4 1/2	1 3/8	3/8	.375	1 1/4	48
5	1 1/2	3/8	.375	1 3/8	40
6	1 5/8	3/8	.375	1 1/2	28
6 1/2	1 7/8	3/8	.375	1 3/4	24
7	2 1/8	3/8	.375	2	21

Planer Head Bolt Washers

Dia. of bolt............	1/2	9/16	5/8	11/16	3/4
" " washer..........	1 7/16	1 7/16	1 1/2	1 9/16	1 13/16
Thickness of washer......	1/16	1/16	1/16	1/16	9/32

O. G. Cast Iron Washers



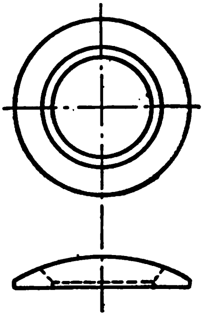
Dia. of Bolt, Inches	A	B	C	D	E	Approximate Weight Each
3/8	1	1/2	7/16	1 1/4	7/16	2 1/2 oz.
1/2	1 5/8	11/16	5/8	2 1/2	1/2	7 oz.
5/8	2	13/16	3/4	3	5/8	12 oz.
3/4	2	15/16	7/8	3	3/4	1 lb.
7/8	2 1/2	1 1/16	1	3 1/2	7/8	1 lb. 6 oz.
1	2 1/2	1 3/16	1 1/8	4	1	2 lb.
1 1/8	2 7/8	1 5/16	1 1/4	4 1/2	1 1/8	2 lb. 6 oz.
1 1/4	3 1/2	1 7/16	1 3/8	5 1/4	1 1/4	4 lb. 4 oz.
1 3/8	3 1/2	1 9/16	1 1/2	5 1/4	1 1/4	4 lb. 4 oz.
1 1/2	3 1/4	1 11/16	1 5/8	6	1 1/2	6 lb.

Washers for Screws

Dia. of Screw	Dia. of Washer	Thickness
1/8	11/16	5/32
3/16	13/16	3/16
1/4	15/16	1/4
5/16	1 1/16	5/16
3/8	1 3/16	3/8
3/8	1 7/16	3/8
7/16	1 11/16	7/16
1/2	1 15/16	1/2
1/2	2 3/16	1/2

CLINCH RINGS

Counter Sunk or Recessed Hole



Size of Hole, Ins.	Outside dia., Ins.	Thickness Ins.	Number in one Lb.	Size of Hole, Ins.	Outside dia., Ins.	Thickness Ins.	Number in one Lb.
1/2	1 3/8	3/16	18	1	2 1/8	9/32	5
5/8	1 1/2	7/32	15	1 1/8	2 3/8	5/16	3 3/4
3/4	1 5/8	7/32	11	1 1/4	2 5/8	5/16	2 3/4
7/8	1 3/4	7/32	10	1 3/8	2 7/8	7/16	2 1/4

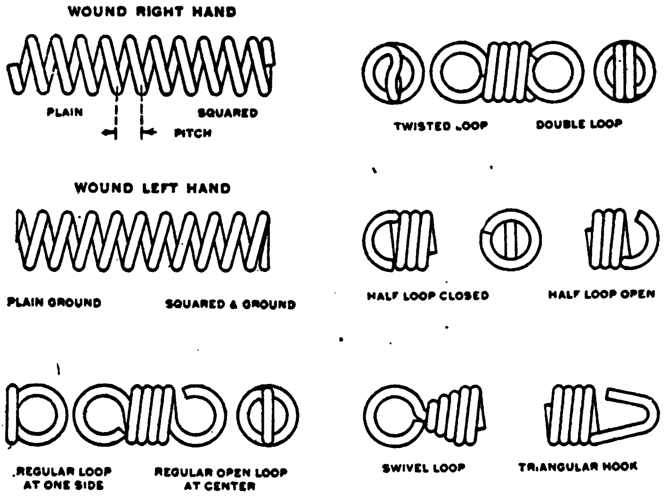
Straight Hole

Size of Hole, Ins.	Outside Dia., Ins.	Thickness Ins.	Size of Hole Ins.	Outside Dia., Ins.	Thickness Ins.
5/16	3/4	1/8	3/4	1 9/16	7/32
3/8	15/16	5/32	7/8	2	7/32
7/16	1	5/32	1	2	9/32
1/2	1 1/16	3/16	1 1/4	2 9/16	5/16
5/8	1 7/16	7/32	1 3/8	2 7/8	7/16

SPRINGS

In general a helical compression spring will give the best results if its outside diameter equals eight times the diameter of the wire. In designing compression springs with squared ends, two inactive coils should be allowed for squaring.

The load a spring will sustain can be increased by increasing the diameter of the wire, diminishing the number of coils or decreasing the outside diameter.



Torsion springs should be so designed that their action will be in the direction that tends to reduce the diameter of the spring.

Specifications for Ordering Springs

Compression Type

Material.
Size of wire.
Inside diameter if spring works on a rod.
Outside " " " " in " hole.
Free length.
Pitch, or number of coils.
Style of ends, whether plain, squared only, ground only or squared and ground.
Distance to be compressed and with what weight or power.

Extension Type

Material.
Size of wire.
Outside diameter.
Length of coils in inches, or number of coils.
Length over all.
Style of ends, whether loop or hook, parallel or at right angles.
Distance to be extended and with what weight or power.

[W. Barnes Co., Bristol, Conn.]

SPRING FORMULÆ

P = safe load in lbs.	r = mean radius of coil
E = modulus of elasticity	d = dia. of coil wire
G = modulus of torsion	l = length of spring
s = safe shearing stress in lbs. per sq. in.	n = number of coils
f = deflection of spring in ins. for load P.	π = 3.1416

SPRING IN COMPRESSION OR TENSION WHEN LOADED AXIALLY

Cylindrical helical spring, circular cross section. $P = \frac{s\pi d^3}{16r}$; $f = \frac{32\ Plr^2}{\pi d^4 G} = \frac{64\ Pnr^3}{d^4 G}$.

Rectangular cross section, t = thickness, w = width. $P = \frac{st^2w^2}{3r\sqrt{t^2+w^2}}$; $f = \frac{3\ Pr^2l\ (t^2+w^2)}{Gt^3w^3}$.

SPRING SUBJECT TO BENDING

Rectangular plate $P = \frac{St^2w}{6l}$; $f = \frac{Pl^3}{Et^3w}$.

Triangular plate $P = \frac{St^2w}{6l}$; $f = \frac{6\ Pl^3}{Et^3w}$.

Compound (leaf or laminated) triangular plates. k = number of plates. $P = \frac{Skt^2w}{6l}$; $f = \frac{6\ Pl^3}{Ekt^3w}$.

TABLE FOR DETERMINING CAPACITIES

D = Outside Diam. of Spring. W = Safe Load

Note—To find values for square wire multiply the

Size of Wire	D	.250	.3125	.375	.4375	.500	.5625	.625	.750	.875	1.000	1.125	1.250
#26	W	.41	.31	.27	.23	.20	.175	.16	.13	.11	.098		
.016	F	.1302	.302	.470	.760	1.150	1.66	2.30	4.02	6.95	9.42		
#24	W	1.18	.92	.76	.45	.56	.50	.45	.37	.31	.28	.24	
.0225	F	.0278	.0631	.1135	.1857	.282	.408	.569	.975	1.66	2.42	3.46	
#22	W	2.35	1.84	1.49	1.26	1.095	.96	.865	.715	.61	.53	.47	
.028	F	.0119	.0250	.0453	.0742	.1140	.165	.231	.408	.660	.995	1.42	
#20	W	4.70	3.64	2.97	2.5	2.18	1.92	1.72	1.42	1.20	1.05	.93	.84
.035	F	.00451	.00952	.0175	.0290	.0447	.0651	.0914	.163	.264	.400	.575	.792
#19	W	7.87	6.05	4.93	4.15	3.58	3.16	2.82	2.32	1.97	1.74	1.54	1.34
.041	F	.00234	.0047	.0088	.0106	.0228	.0334	.0410	.0842	.1370	.208	.305	.430
#18	W	12.05	9.2	7.40	6.57	5.4	4.75	4.23	3.48	2.95	2.85	2.27	2.02
.047	F	.00115	.00294	.00488	.00824	.0132	.0187	.0264	.0396	.0785	.126	.175	.242
#17	W	18.9	14.3	11.5	9.67	8.3	7.3	6.47	5.32	4.5	3.91	3.45	3.1
.054	F	.00059	.00138	.00256	.0044	.00702	.0103	.0145	.0267	.0437	.067	.0971	.1502
#16	W	31.5	23.61	18.8	15.7	13.8	11.8	10.5	8.57	7.25	6.28	5.04	4.96
.063	F	.00026	.00065	.00122	.00222	.0051	.0053	.00704	.0129	.0233	.0327	.0476	.066
#15	W			29	24.1	20.5	17.9	15.85	12.92	10.9	9.46	8.35	7.45
.072	F			.00066	.0012	.0018	.0029	.00404	.0074	.0124	.0189	.0279	.039
#14	W			41	33.5	28.8	24.9	22.2	18.1	15.2	13.15	11.6	10.35
.080	F			.00041	.00074	.00128	.00203	.0034	.0057	.0082	.0127	.0186	.026
#13	W					45.7	40.7	35	28.4	23.8	20.3	17.75	16.15
.092	F					.00063	.00085	.0014	.00266	.0045	.0072	.01035	.0148
#12	W							52.5	42.2	35.4	30.4	26 74	23.8
.105	F							.00069	.00148	.0026	.0039	.0058	.0083
#11	W								65	54	46	40.51	36
.120	F								.0008	.0013	.00219	.00326	.0046
#10	W									77	67	58.6	52
.135	F									.00081	.00135	.0019	.0027
# 9	W									105	90	78	69
.148	F									.00053	.00035	.00129	.0019
# 8	W										120	104	98
.162	F										.00057	.00087	.0012
# 7	W										159	138	122
.177	F										.00038	.00058	.00083
# 6	W												158
.192	F												.00057
# 5	W												
.203	F												
# 4	W												
.225	F												
# 3	W												
.244	F												
# 2	W												
.263	F												
# 1	W												
.283	F												
# 0	W												
.307	F												
#00	W												
.331	F												
#000	W												
.362	F												

ILLUSTRATION OF THE USE

Required a spring ½″ O. D. that will give a resistance of 42 lbs. when compressed to a length of 3″.

1. What size of wire is required?
2. What will be the uncompressed length of the spring?
3. How many coils?

In the table we follow the horizontal column, giving the values of D, until we come to the vertical column captioned .500 (½″ O. D.)

Searching down this column we find 45.7 lbs. as the nearest W. (safe load) value to the 42 lbs. required.

Glancing from this point toward the left we find the size wire to be .092″ and the F Value (deflection of one coil under one lb.) to be .00063.

We therefore have .00063 x 42 equal to .026 + as the deflection of one coil under a load of 42 lbs.

for Round Wire Helical Springs

in Lbs. F = Deflection of One Coil per One Lb.

given safe load by 1.2 and the given deflection by .59.

1.375	1.500	1.750	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.50	5.00
1.84													
.320													
.281	.256												
.181	.228												
4.49	4.1	3.50											
.0953	.118	.190											
6.75	6.15	5.25	4.53										
.0548	.0697	.116	.204										
9.32	8.52	7.25	6.3	5.56									
.0354	.0548	.0757	.116	.166									
14.40	13.15	11.25	9.72	8.65	7.75								
.0197	.0266	.0425	.0658	.080	.131								
21.48	19.5	16.6	14.4	12.7	11.4	10.3							
.01124	.0149	.0245	.0374	.0545	.0734	.102							
32.44	29	25	22	19	17	15.5	14						
.0064	.0084	.0139	.0213	.0311	.0433	.0568	.077						
46.75	42	36	31	27	24	22	20	18					
.0038	.0051	.0084	.0129	.0191	.0266	.0358	.0475	.0608					
62.4	56	47	41	38	32	29	27	24	23				
.00257	.00317	.0056	.0078	.0131	.018	.024	.0313	.0413	.0522				
32.5	76	64	55	49	43	39	36	33	30				
.00173	.0020	.0055	.0059	.0088	.0126	.0168	.022	.0285	.0364				
109	99	83	72	62	56	51	46	42	39	37			
.0012	.0015	.0026	.0041	.006	.0083	.0115	.0154	.0196	.0249	.031			
143	128	107	92	81	72	65	59	55	50	47	44		
.00081	.0011	.0018	.0028	.0042	.0059	.008	.0107	.0138	.0174	.0222	.0266		
174	155	131	113	99	88	80	70	67	61	57	53	47	
.0006	.0008	.0014	.0022	.0032	.0041	.0062	.0082	.0106	.0134	.0168	.0222	.0298	
233	210	175	150	132	118	106	97	89	82	77	71	63	57
.00041	.0005	.0009	.0015	.0022	.003	.0041	.0065	.0071	.0091	.0113	.013	.0202	.028
	250	225	195	170	152	136	125	114	105	98	88	80	72
	.0004	.0005	.0008	.0012	.00198	.0029	.0039	.0051	.0065	.0081	.0086	.0116	.020
	345	290	250	215	192	175	156	146	134	123	115	100	90.5
	.0003	.00046	.00072	.0011	.0015	.0021	.0027	.0037	.0047	.0059	.0072	.0106	.0148
		360	310	270	240	215	195	180	165	154	145	127	113
		.00031	.00055	.00078	.0011	.0015	.0021	.0027	.0034	.0044	.0053	.0077	.0128
		470	400	350	310	280	250	230	212	198	185	162	145
		.0003	.00038	.00055	.00079	.0011	.0015	.002	.0024	.0030	.0033	.0055	.0077
			510	445	390	350	320	290	270	250	230	205	183
			.00029	.00039	.00056	.00078	.001	.0014	.0017	.0022	.0027	.0041	.0056
			700	610	540	480	435	400	365	330	315	280	250
			.00017	.00026	.00038	.00053	.00071	.00094	.0012	.0015	.00186	.00276	.0033

OF THE ABOVE TABLE

Assuming that the spring is not to be at its solid height when compressed to the specified 3″ we have 3″ divided by .092 equal to 32.6 coils as the number in the solid height or 30 coils as a desirable number for the spring.

There being 28 free coils in a spring containing 30 coils we have 28 multiplied by .026 equal to .728 as the total deflection of the spring when resisting a load of 42 lbs.

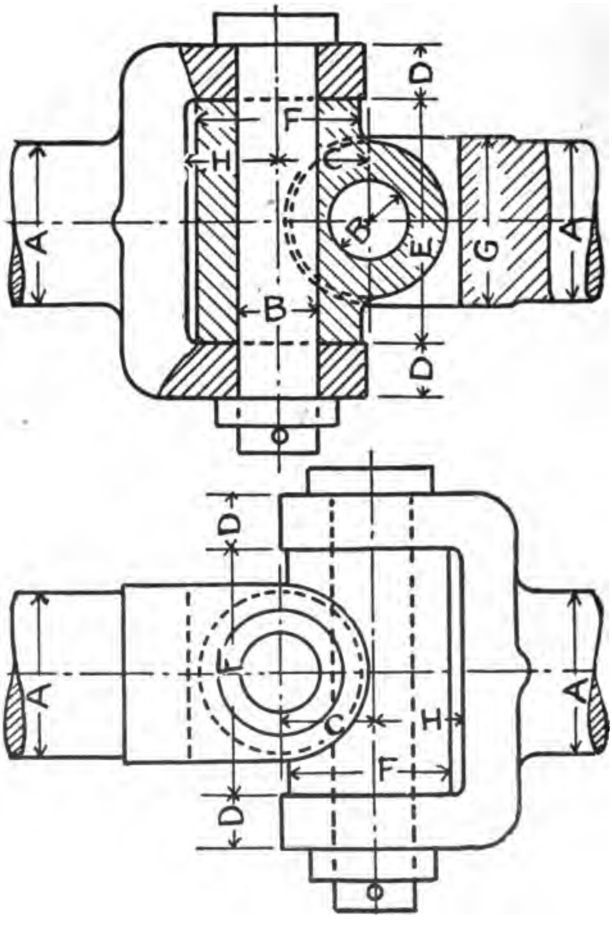
We have then: .092 as the size wire required 3″ + .728 = 3.728 as the free length. Thirty as the number of coils.

Note: The above tables are not guaranteed to be absolutely correct, as allowances have to be made for various grades of material. They will, however, be a good working basis for general estimating and experimental purposes.

ANGLE COUPLINGS

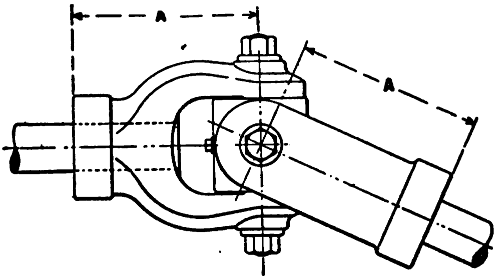
(Universal Joints)

SINGLE ANGLE COUPLING



A = d = dia. of shaft	E = 1.5 d
B = .5 d	F = d
C = .56 d	G = 1.1 d
D = .32 d	H = .56 d

SINGLE ANGLE COUPLING



Will work to an angle of 25 degs.

Dia. of Shaft Inches	A Inches	Dia. of Shaft Inches	A Inches	Dia. of Shaft Inches	A Inches
15/16	3½	2 3/16	8	3 15/16	14
1 3/16	4½	2 7/16	10	4 7/16	16
1 7/16	6¼	2 11/16	10	4 15/16	20
1 11/16	6¼	2 15/16	11½		
1 15/16	8	3 7/16	11½		

[A. & F. Brown, Elizabeth, N. J.]

With single angle couplings the angular velocity is variable and is dependent on the angle of inclination of the shafts. The variation is of little consequence except where extreme accuracy is required as in time recording machines.

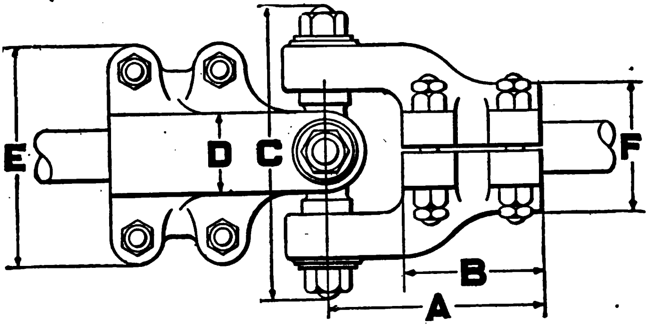
The joint shown is often installed in line shafts of motor boats and in shafts from engine to driving gear on the rear axle of automobiles.

The shafts in coupling on page 255 are keyed or pinned in, while those on page 256 are keyed and the parts held together by bolts.

Angle couplings are sometimes called Hooke's joints.

The type shown on page 254 is more frequently used where the angle between the shafts is large.

Single Angle Coupling

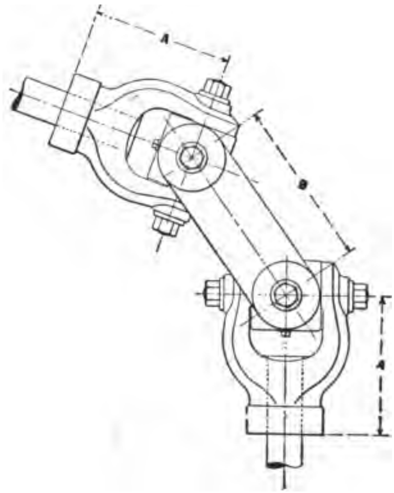


Will work to an angle of 25 degs.

Dia. of Shaft	A	B	C	D	E	F	Standard Keyway
$1\frac{3}{16}$	$8\frac{1}{2}$	$4\frac{1}{4}$	$7\frac{1}{2}$	2	$4\frac{1}{2}$	$3\frac{1}{4}$	$\frac{7}{32}$
$1\frac{7}{16}$	9	$4\frac{1}{2}$	$7\frac{3}{4}$	$2\frac{1}{4}$	5	$3\frac{1}{2}$	$\frac{5}{16}$
$1\frac{11}{16}$	$9\frac{3}{4}$	5	$8\frac{1}{2}$	$2\frac{1}{2}$	$5\frac{1}{2}$	4	$\frac{7}{16}$
$1\frac{15}{16}$	10	6	10	$3\frac{1}{4}$	7	$4\frac{3}{4}$	$\frac{7}{16}$
$2\frac{3}{16}$	11	$6\frac{1}{2}$	$10\frac{3}{4}$	$3\frac{3}{4}$	$7\frac{1}{2}$	$5\frac{3}{4}$	$\frac{9}{16}$
$2\frac{7}{16}$	12	7	$11\frac{1}{2}$	4	$7\frac{3}{4}$	6	$\frac{9}{16}$
$2\frac{11}{16}$	$12\frac{1}{2}$	$7\frac{1}{2}$	$12\frac{1}{4}$	4	$8\frac{3}{4}$	$6\frac{3}{4}$	$\frac{11}{16}$
$2\frac{15}{16}$	$12\frac{3}{4}$	$8\frac{1}{4}$	13	$4\frac{3}{4}$	$9\frac{3}{4}$	$7\frac{1}{2}$	$\frac{11}{16}$
$3\frac{3}{16}$	$13\frac{1}{2}$	$8\frac{3}{4}$	$14\frac{1}{2}$	5	$10\frac{1}{4}$	8	$\frac{11}{16}$
$3\frac{7}{16}$	$14\frac{1}{4}$	9	16	5	$10\frac{1}{2}$	$8\frac{1}{2}$	$\frac{11}{16}$
$3\frac{15}{16}$	$15\frac{1}{2}$	10	18	$5\frac{1}{2}$	$11\frac{1}{2}$	$8\frac{1}{2}$	$\frac{13}{16}$
$4\frac{7}{16}$	$16\frac{1}{2}$	$10\frac{3}{4}$	20	6	$12\frac{1}{2}$	$9\frac{1}{4}$	$\frac{13}{16}$
$4\frac{15}{16}$	$17\frac{3}{4}$	$11\frac{1}{2}$	22	$6\frac{1}{2}$	$13\frac{1}{2}$	10	$\frac{13}{16}$

[Cresson-Morris Co., Phila., Pa.]

Double Angle Coupling

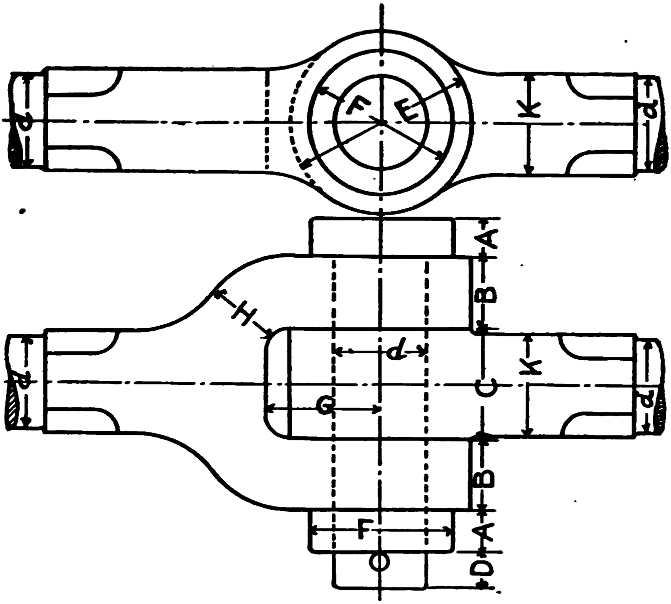


Will work to an angle of 70 degs.

Dia. of Shaft Ins.	A Ins.	B Ins.	Dia. of Shaft Ins.	A Ins.	B Ins.	Dia. of Shaft Ins.	A Ins.	B Ins.
15/16	3 1/2	4 3/4	2 3/16	8	10	3 15/16	14	17 1/2
1 3/16	4 1/2	5 1/2	2 7/16	10	12 3/4	4 7/16	16	20
1 7/16	6 1/4	8 1/4	2 11/16	10	12 3/4	4 15/16	20	24
1 11/16	8	8 1/4	2 15/16	11 1/2	14 1/2			
1 15/16	8	10	3 7/16	11 1/2	14 1/2			

The variation in angular velocity is overcome by two single angle joints connecting two parallel shafts through an intermediate shaft.

KNUCKLE JOINTS



d = diameter of pin	
A = .43 d	F = 1.5 d
B = .75 d	G = 1.25 d
C = 1.25 d	H = .9 d
D = .43 d	K = 1.1 d
E = 1.93 d	

Diameter of head of pin same as washer F.

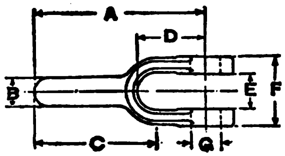
For tables of yoke and rod ends for forming knuckle joints see pages 259–261.

YOKE ENDS

Dimensions of yoke and rod ends given in the following tables are of steel, drop forged. The dimensions can be followed in making castings of iron and composition, but neither will be equivalent to steel in strength.

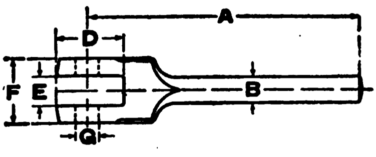
Plain

Society of Automotive Engineers' Standard



A	B	C	D	E	F	G
1¼	3/16	⅞	7/16	3/16	7/16	3/16
1¾	¼	1¼	⅝	9/32	⅝	¼
2	5/16	1⅜	¾	11/32	¾	5/16
2⅛	⅜	1 7/16	27/32	7/16	⅞	⅜
2¼	7/16	1½	1	½	1	7/16
2½	½	1⅝	1⅛	9/16	1⅛	½

Billings and Spencer Standard



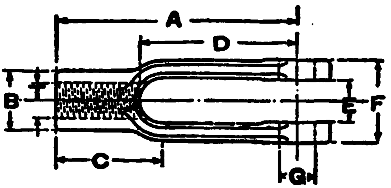
(See next page for table.)

Billings and Spencer Standard

A	B	D	E	F	G
4 1/2	1/4	25/32	5/16	3/4	5/16
4 3/4	5/16	15/16	3/8	7/8	5/16
5	3/8	1 1/16	7/16	1	3/8
5 1/4	7/16	1 5/32	1/2	1 1/8	7/16
5 1/2	1/2	1 5/16	9/16	1 1/4	1/2
5 3/4	9/16	1 7/16	5/8	1 3/8	9/16
6 1/4	5/8	1 5/8	3/4	1 5/8	5/8
7	3/4	1 15/16	7/8	1 7/8	3/4
7 3/4	7/8	2 7/32	1	2 3/16	7/8
8 1/2	1	2 17/32	1 1/8	2 1/2	1
9 1/4	1 1/8	2 29/32	1 1/4	2 13/16	1 1/8
10	1 1/4	3 7/32	1 3/8	3 1/8	1 1/4

Adjustable

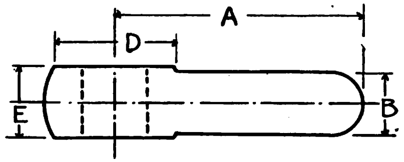
Society of Automotive Engineers' Standard



A	B	C	D	E	F	G	T	
							Dia.	S. A. E. threads per inch
2	7/16	7/8	1 1/4	9/32	5/8	1/4	1/4	28
2 1/4	1/2	1	1 7/16	11/32	3/4	5/16	5/16	24
2 1/2	5/8	1 1/8	1 5/8	7/16	7/8	3/8	3/8	24
2 7/8	23/32	1 1/4	1 7/8	1/2	1	7/16	7/16	20
3	13/16	1 3/8	1 7/8	9/16	1 1/8	1/2	1/2	20

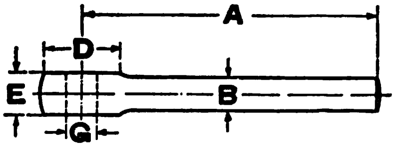
ROD ENDS

Society of Automotive Engineers' Standard



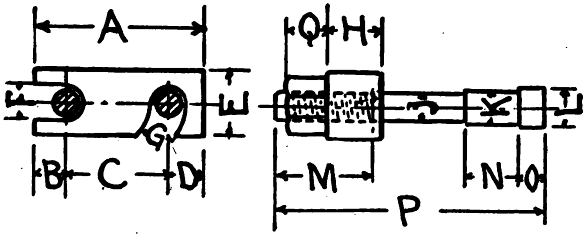
A	B	D	E	Dia. of Hole
1¼	3/16	3/8	3/16	3/16
1¼	¼	½	9/32	¼
1⅜	5/16	19/32	11/32	5/16
1½	3/8	11/16	7/16	3/8
1½	7/16	13/16	½	7/16
1¾	½	15/16	9/16	½

Billings and Spencer Standard

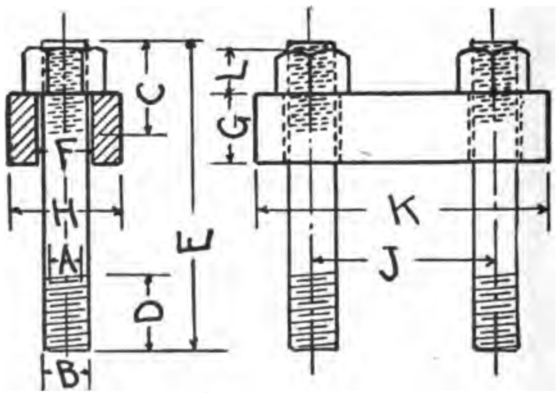


A	B	D	E	G
3 15/16	¼	11/16	5/16	5/16
4 1/16	5/16	13/16	3/8	5/16
4¼	3/8	7/8	7/16	3/8
4 7/16	7/16	1	½	7/16
4⅝	½	1⅛	9/16	½
4 13/16	9/16	1¼	5/8	9/16
5 3/16	5/8	1½	¾	5/8
5 9/16	¾	1¾	7/8	¾
6 3/32	7/8	2	1	7/8
6½	1	2¼	1⅛	1
7 1/32	1⅛	2 9/16	1¼	1⅛
7 9/16	1¼	2⅞	1⅜	1¼

TOOL STRAPS AND BOLTS



Strap								Bolt							Nut
A	B	C	D	E	F	G	H	J	K	L	M	N	O	P	Q
5	1	3	1	1¾	13/16	13/16	1½	¾	13/16	1 1/16	3¾	1 13/32	13/16	7½	1¼
5	1	3	1	1½	13/16	13/16	1½	¾	13/16	1	2½	1 31/32	⅜	7⅛	1¼
6	1¼	3½	1¼	1¾	15/16	15/16	1¾	⅞	15/16	1 3/16	4¼	2 1/16	23/32	8 31/32	1½
6	1⅛	3¾	1⅛	2⅛	1 1/16	1 1/16	2⅛	1	1 1/16	1 9/16	4¾	2 1/16	¾	9⅝	1⅝
7	1 3/16	4⅝	1 3/16	2⅛	1 3/16	1 3/16	2⅛	1⅛	1 3/16	1 11/16	4 15/16	2 9/16	¾	10¾	1¾
7½	1 5/16	4⅞	1 5/16	2⅛	1 3/16	1 3/16	2⅛	1⅛	1¼	1 13/16	5¼	2¾	¾	12	1¾
8¼	1¼	5¾	1¼	2⅜	1 5/16	1 5/16	2⅜	1¼	1 5/16	1 15/16	8 15/16	3 5/16	¾	2	15¼



For dimensions see page 263.

Bolt					Strap					Nut
B dia. of bolt	A dia. at root of thread	C	D	E	F	G	H	J	K	L
3/4	.620	2 1/8	1 1/4	6 1/4	7/8	1 1/2	1 1/2	4	7	1 1/4
1	.838	3	1 3/4	8 1/2	1 1/8	2	2	6	9	1 5/8
1 1/8	.939	2 3/4	1 7/8	9 1/8	1 1/4	2 1/8	2 1/8	5 1/2	9 3/4	1 3/4
1 1/8	.939	5 1/2	2	10 1/4	1 1/4	2 1/8	2 1/8	6	10 3/4	1 3/4
1 1/4	1.064	5	2 1/2	12	1 3/8	2 1/2	2 1/2	8	14	2
1 1/4	1.064	3 1/2	1 3/4	9 1/4	1 3/8	2	2 1/2	5 1/2	10	2
1 3/4	1.490	5	2 1/2	13	1 7/8	3 1/4	3 1/4	10 1/2	18	2 1/2

[Niles-Bement-Pond Co., New York.]

MATERIALS OF MACHINE PARTS

Cast Iron—weak in tension and strong in compression. Tensile strength 22,500 lbs. per sq. in., compression 90,000. Weight per cu. ft. 449 lbs.

Malleable Iron—cast iron heated in retorts with an oxide of iron. Malleable iron has a tough outside surface like wrought iron and an interior like cast iron. Pipe fittings often made of it. Tensile strength 37,000 lbs.

Wrought Iron—tough, ductile, weldable but cannot be tempered. Tensile strength 50,000 lbs., compression 55,000. Weight per cu. ft. 485 lbs.

Composition or Brass—copper 65.3%, zinc 32.7%, lead 2%. The lead content makes a soft brass that can be readily machined. Navy brass 62% copper, 36 to 37% zinc, 1 to 1½% tin. Weight per cu. ft. 505 lbs.

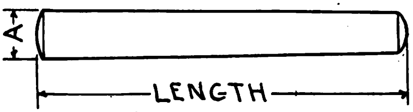
Cast Steel—has a lower carbon content than cast iron, and is used for parts which would be too weak if made of iron. Tensile strength 60,000 lbs. Weight per cu. ft. 490 lbs.

Bronze—as ordinarily understood is an alloy of copper and tin, varying from 8 to 25% of tin. Other metals may be added as phosphorus, making an alloy known as phosphor bronze containing 82.2% copper, 12.95% tin, 4.28% lead and .52% phosphorus. This bronze has a tensile strength of about 50,000 lbs. Weight per cu. ft. 508 lbs.

TAPER PINS

The pins should force the parts together, and in proper relation to each other when driven home, thus preventing the pins from working loose. They are made of steel and finished all over.

Plain

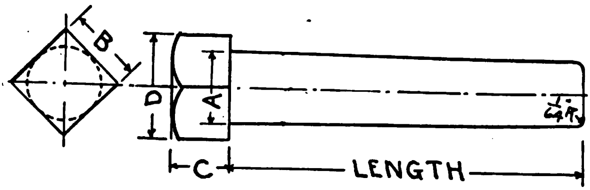


A	Approximate Equivalent	A	Approximate Equivalent
.156	5/32	.341	11/32
.172	11/64	.409	13/32
.193	3/16	.492	1/2
.219	7/32	.591	19/32
.250	1/4	706	45/64
.289	19/64		

Taper 1/4″ in 12″.
Lengths 5/8″, 1″ to 5 3/4″ advancing by 1/4″.

[Cincinnati Bickford Tool Co., Cincinnati, O.]

Square Head



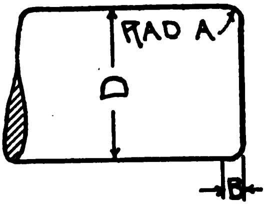
For dimensions see page 265.

A	Approximate Equivalent	B	C	D
.156	5/32	1/4	3/16	11/32
.172	11/64	1/4	3/16	11/32
.193	3/16	1/4	3/16	11/32
.219	7/32	1/4	3/16	11/32
.250	1/4	3/8	1/4	17/32
.289	19/64	3/8	1/4	17/32
.341	11/32	3/8	1/4	17/32
.409	13/32	1/2	3/8	23/32
.492	1/2	1/2	3/8	23/32
.591	9/32	3/4	1/2	1 1/16
706	45/64	3/4	1/2	1 1/16

Taper 1/4″ in 12″.
Lengths from 3/4″ to 5 1/2″ advancing by 1/4″.
[Cincinnati Bickford Tool Co., Cincinnati, O.]

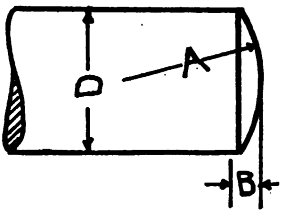
FINISHED ENDS OF SHAFTS, BOLTS AND BUSHINGS

Solid or Hollow Shafts



Dia. of Shaft D	A	B End of Shaft to Bearing
1/4 to 1/2	1/32	1/16
9/16 " 1	1/16	3/32
1 1/16 " 2	3/32	1/8
2 1/16 " 3	1/8	3/16
3 1/16 " 4	5/32	3/16
4 1/16 " 6	3/16	1/4
6 " 8	1/4	3/8

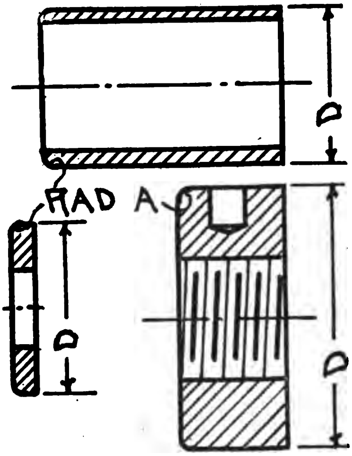
Bolts

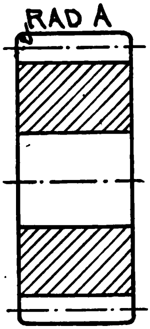


Dia. of D	A	B
1/4 to 7/16	11/32	1/16
1/2 " 11/16	19/32	3/32
3/4 " 15/16	27/32	1/8
1 " 1 1/4	1 1/8	5/32
1 5/16 " 1 5/8	1 15/32	7/32

Bushes, Sleeves, Collars and Washers

Dia. of Bush D	A
1/4 to 1	1/32
1 1/16 " 2	1/16
2 1/16 " 5	3/32
5 1/16 " 8	1/8





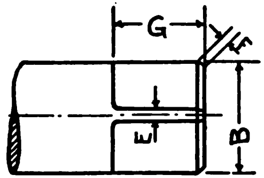
Gears and Racks

Diametral Pitch	Circular Pitch	A
1 to 1 1/4	3.142 to 2.513	1/2
1 1/2 " 2	2.094 " 1.571	1/4
2 1/4 " 3	1.396 " 1.047	3/16
3 1/2 " 4	.898 " .785	1/8
5 " 7	.628 " .449	3/32
8 " 10	.393 " .314	1/16
11 " 16	.286 " .196	1/32

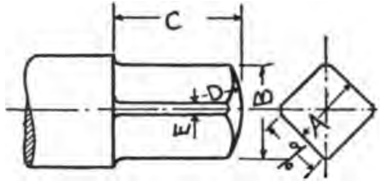
[Gisholt Mach. Co., Madison, Wis.]

Screw points—see page 42.
Nail points—see page 78.

STANDARD SQUARES FOR CHUCK SCREWS AND WRENCHES



CHUCK WRENCH



CHUCK SCREW

A..........	1/8	5/32	3/16	7/32	1/4	5/16	3/8	13/32	7/16	15/32	1/2	9/16	5/8	11/16	3/4	7/8	1	1 1/8	1 1/4
B..........	5/32	13/64	15/64	9/32	5/16	13/32	31/64	17/32	9/16	19/32	21/32	23/32	13/16	7/8	31/32	1 1/8	1 5/16	1 1/2	1 5/8
C..........	3/16	1/4	9/32	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	15/16	1	1 1/8	1 5/16	1 1/2	1 11/16	1 7/8
D..........	1/4	5/16	3/8	13/32	15/32	9/16	5/8	3/4	13/16	7/8	15/16	1	1 1/8	1 5/16	1 7/16	1 11/16	1 15/16	2 1/4	2 1/2
E..........	.021	.018	.031	.029	.041	.036	.046	.043	.055	.068	.051	.078	.072	.097	.094	.112	.101	.092	.142
% of A.....	76	83	76	81	77	84	77	85	82	79	85	80	83	80	82	82	86	88	84
Sharp Corners..	.177	.221	.265	.310	.353	.442	.530	.574	.618	.662	.707	.796	.884	.972	1.062	1.237	1.414	1.592	1.767
F..........	1/64	1/64	1/64	1/64	1/32	1/32	1/32	1/32	3/64	3/64	3/64	1/16	1/16	1/16	1/16	1/16	3/32	3/32	3/32
G..........	3/16	1/4	1/4	5/16	5/16	3/8	7/16	1/2	9/16	9/16	5/8	11/16	3/4	13/16	7/8	1	1 1/4	1 3/8	1 1/2

[Gisholt Machine Co., Madison, Wis.]

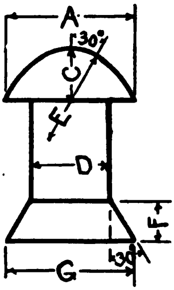
SECTION VII

STRUCTURAL DETAILS

RIVETS—RIVETED JOINTS—STRUCTURAL SHAPES—PLATES—WIRE AND SHEET METAL GAUGES—GAUGES FOR PUNCHING—RIVET SPACING—BEAM CONNECTIONS

RIVETS

There are no universal proportions for structural and ship rivets, but those given on the following pages represent good practice.



STRUCTURAL RIVETS

American Bridge Co. Standard

Full driven head, diameter, $A = 1.5\,D + \frac{1}{8}$

Full driven head, depth, $C = .425\,A$

Full driven head, radius, $E = 1.5\,C$

Countersunk head, depth, $F = .5\,D$

Countersunk head, diameter, $G = 1.577\,D$

Dia. D	A	C	E	F	G
3/8	11/16	19/64	7/16	3/16	19/32
1/2	7/8	3/8	9/16	1/4	25/32
5/8	1 1/16	29/64	29/64	5/16	1
3/4	1 1/4	17/32	51/64	3/8	1 3/16
7/8	1 7/16	39/64	59/64	7/16	1 3/8
1	1 5/8	11/16	1 1/32	1/2	1 9/16
1 1/8	1 13/16	49/64	1 5/32	9/16	1 3/4
1 1/4	2	27/32	1 9/32	5/8	1 15/16

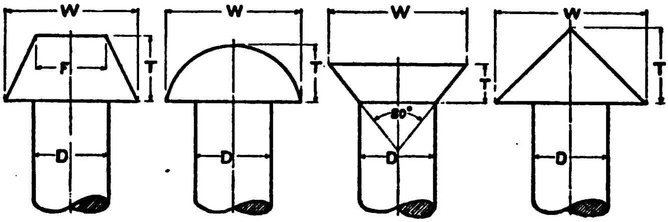
RIVET HEADS

Button heads for structural work. Pan and flush for ship. For steeple head, see page 270.

Points for structural work are generally button while for ship they may be either button or flush, and for boilers, steeple.

Rivet Head Formulæ

Hoopes & Townsend



Cone Head . . $\begin{cases} D \times 1.75 = W \\ D \times .875 = T \\ D \times .9375 = F \end{cases}$

Button Head $\begin{cases} D \times 1.75 = W \\ D \times .75 = T \end{cases}$

Countersunk Head D x .50 = T

Steeple Head . . . . $\begin{cases} D \times 2. = W \\ D \times 1. = T \end{cases}$

Sizes of Rivet Heads

Diameter	Cone			Button		Countersunk		Steeple	
	Wide	Thick	Top	Wide	Thick	Wide	Thick	Wide	Thick
1/2	7/8	7/16	15/32	7/8	3/8	15/16	1/4	1	1/2
9/16	63/64	1/2	17/32	63/64	27/64	1 1/16	9/32	1 1/8	9/16
5/8	1 3/32	35/64	37/64	1 3/32	15/32	1 5/32	5/16	1 1/4	5/8
11/16	1 13/64	39/64	41/64	1 13/64	33/64	1 1/4	11/32	1 3/8	11/16
3/4	1 5/16	21/32	45/64	1 5/16	9/16	1 3/8	3/8	1 1/2	3/4
13/16	1 27/64	45/64	49/64	1 27/64	39/64	1 1/2	13/32	1 5/8	13/16
7/8	1 17/32	49/64	53/64	1 17/32	21/32	1 5/8	7/16	1 3/4	7/8
15/16	1 41/64	13/16	7/8	1 41/64	45/64	1 3/4	15/32	1 7/8	15/16
1	1 3/4	7/8	15/16	1 3/4	3/4	1 13/16	1/2	2	1
1 1/16	1 55/64	59/64	1	1 55/64	51/64	1 31/32	17/32	2 1/8	1 1/16
1 1/8	1 31/32	63/64	1 1/16	1 31/32	27/32	2 1/16	9/16	2 1/4	1 1/8
1 3/16	2 5/64	1 1/32	1 7/64	2 5/64	57/64	2 3/16	19/32	2 3/8	1 3/16
1 1/4	2 3/16	1 3/32	1 11/64	2 3/16	15/16	2 5/16	5/8	2 1/2	1 1/4

Champion Rivet Co., Cleveland, Ohio

let d = dia. of rivet

Cone Head. Least dia. = $^{15}/_{16} \times$ d
Greatest dia. = 1.75 $\times$ d
Height = $^{7}/_{8} \times$ d

Button Head. Dia. = 1.75 $\times$ d
Height = .75 $\times$ d

Steeple Head. Dia. = 2 $\times$ d
Height = $1^{1}/_{8} \times$ d

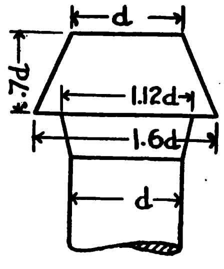
Flat Head Countersunk. Height = $^{1}/_{2} \times$ d. Taper 78 degs.

Pan Head. Greatest dia. = 1.75 $\times$ d
Height = $^{9}/_{16} \times$ d
Flat surface on top of head equals diameter of rivet, tapering in a rounding oval to the outside edge.

Oval Countersunk.. Greatest dia. = 1.75 $\times$ d
78 degs. taper of countersink.
Height of countersink = .5 $\times$ d
" " oval = $^{3}/_{16} \times$ d
Radius of oval = $2^{1}/_{4} \times$ d

SHIP RIVETS

Lloyds



Form of Rivet, in Outside Plating.

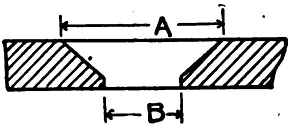
Tapered neck of rivet to be of suitable length in relation to the thickness of plate in which it will be used.

Countersink Rivets.—The countersink is to extend through the whole thickness of the plate when not more than .60 of an inch in thickness, when .60 of an inch or above, the countersink is to extend through nine tenths the thickness of the plate.

Tests.—Rivet shank bent cold on itself without cracking. Heads while hot can be flattened without cracking. Tensile strength 50,000 to 60,000 lbs. per sq. in., with an elongation of not less than 25% of the gauge length of eight times the diameter of the test piece.

Ship Rivets

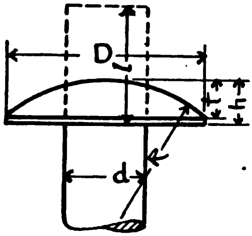
Lloyds



Dia. of Rivet, Ins.	A, Ins.	B, Ins.
$\frac{5}{8}$	1	$\frac{11}{16}$
$\frac{3}{4}$	$1\frac{3}{16}$	$\frac{13}{16}$
$\frac{7}{8}$	$1\frac{3}{8}$	$\frac{15}{16}$
1	$1\frac{9}{16}$	$1\frac{1}{16}$
$1\frac{1}{8}$	$1\frac{3}{4}$	$1\frac{3}{16}$
$1\frac{1}{4}$	$1\frac{15}{16}$	$1\frac{5}{16}$

Truss Head Rivets

$D = 2.5d$
$h = .5d$
$R = 2d$
$t = .4375d$
$l = 1.81d$

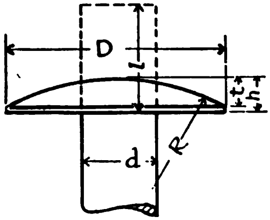


d	D	h	R	t	l
$\frac{1}{8}$	.3125	.0625	.250	.055	.240
$\frac{5}{32}$	.3000	.0780	.312	.0680	.282
$\frac{3}{16}$	.4687	.0937	.375	.082	.360
$\frac{7}{32}$	.5450	.1090	.437	.095	.395
$\frac{1}{4}$	.6250	.1250	.500	.109	.480
$\frac{9}{32}$	.7250	.1400	.562	.125	.510
$\frac{5}{16}$	.7812	.1560	.625	.137	.600
$\frac{3}{8}$	.9375	.1875	.750	.164	.720
$\frac{7}{16}$	1.0937	.2187	.875	.191	.840
$\frac{1}{2}$	1.2500	.2500	1.000	.218	.960

In rivet calculations (page 276) it is customary to disregard friction and proportion rivets to the entire stress to be transmitted.

Wagon Box Head Rivets

$D = 2.8d$
$h = .4375d$
$R = 2.8d$
$t = .375d$



d	D	h	R	t	l
1/8	.350	.0547	.3500	.0467	.285
5/32	.4375	.0680	.4375	.0585	.356
3/16	.525	.0820	.5250	.0700	.427
7/32	.6093	.0950	.6093	.0820	.497
1/4	.7031	.1090	.7031	.0940	.570
9/32	.7812	.1230	.7812	.1050	.644
5/16	.875	.1365	.8750	.1170	.712
3/8	1.050	.1640	1.0500	.1400	.855
7/16	1.220	.1910	1.2200	.1640	.996
1/2	1.400	.2188	1.4000	.1875	1.140

[The Atlas Bolt and Screw Co., Cleveland, Ohio.]

Lengths of Rivets for Ordering

The length for ordering pan and button head rivets is measured exclusive of the head; for countersunk rivets and taps the ordered length includes the head to the top of the countersink.

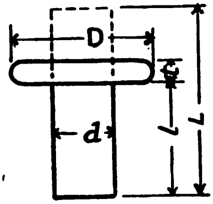
Allowance for Points in Length of Rivets with Two Thicknesses Connected

Type of point	Diameters of Rivets (Ins.)					
	1/2	5/8	3/4	7/8	1	1 1/8
Countersunk.........	1/2	5/8	3/4	7/8	1	1 1/8
Hammered..........	1/2	1/2	1/2	5/8	5/8	5/8
Snap...............	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
Oval...............	7/8	7/8	......	......	......	......

Tinners Rivets

$D = 2.15d$

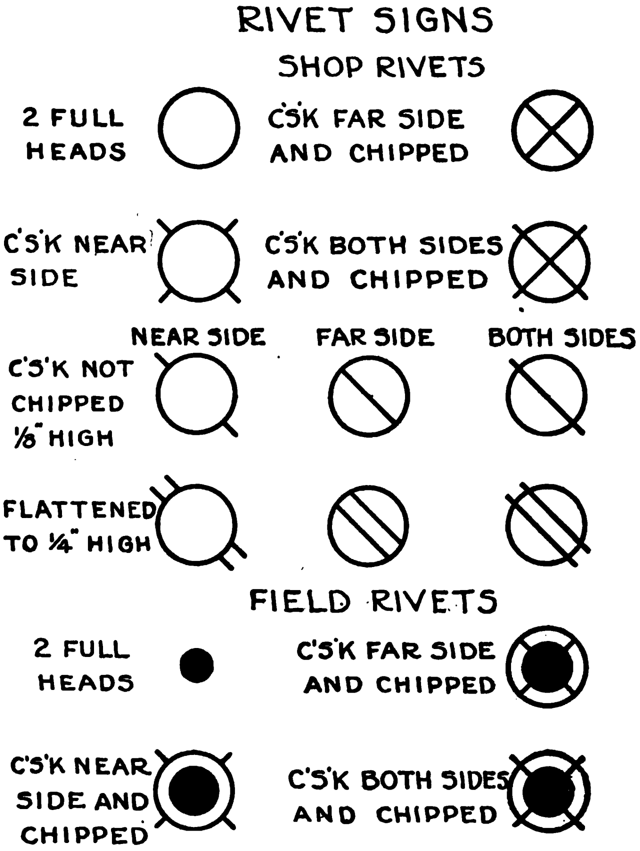
$t = \frac{d}{3}$



Size	Max. Dia. d	l	D	t	L
6 oz.	.082	5/32	11/64	.027	9/32
8 "	.092	5/32	3/16	.031	9/32
10 "	.095	11/64	13/64	.032	5/16
12 "	.106	3/16	7/32	.035	19/64
14 "	.109	3/16	15/64	.036	11/32
1 lb.	.112	13/64	1/4	.037	13/32
1¼ "	.120	7/32	17/64	.040	27/64
1½ "	.130	15/64	9/32	.043	15/32
1¾ "	.134	1/4	19/64	.044	31/64
2 "	.144	17/64	5/16	.048	15/32
2½ "	.148	9/32	21/64	.049	37/64
3 "	.161	5/16	11/32	.053	37/64
3½ "	.165	21/64	43/64	.055	5/8
4 "	.176	11/32	3/8	.058	41/64
4½ "	.181	23/64	25/64	.060	11/16
5 "	.186	3/8	13/32	.062	23/32
6 "	.203	25/64	7/16	.067	11/16
7 "	.216	13/32	15/32	.072	23/32
8 "	.225	7/16	31/64	.075	25/32
9 "	.234	29/64	1/2	.078	49/64
10 "	.238	15/32	33/64	.079	27/32
12 "	.259	1/2	9/16	.086	55/64
14 "	.284	33/64	39/64	.094	53/64
16 "	.300	17/32	41/64	.1	7/8

In ordering rivets, the diameter should be given first and then the length, thus—½" x 3". Rivets are usually shipped in kegs of 100 lbs.

CONVENTIONAL SIGNS FOR RIVETS



Allowable Single Shearing Stress in lbs. per sq. in.

Shop rivets	12,000 lbs.
Field rivets and turned bolts	16,000 "
Field rough bolts	8,000 "

RIVETED JOINTS

Diameter of rivet is 1.2 to 1.4 times $\sqrt{\text{thickness of plate}}$.

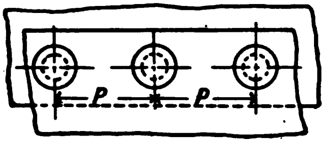
Distance from center of rivet to plate edge 1½ to 2 times the diameter of the rivet; for water tight work use 1⅝.

Water tight spacing 3½ times the diameter of the rivet; oil tight, 3 to 3½ times.

In chain riveting distance between rows of rivets is 2 to 2½ times the diameter of the rivet. In staggered riveting 1.7.

Tensile strength of steel plates generally taken at 60,000 lbs. per sq. in. Shearing strength of rivets 50,000 lbs. per sq. in.

Shearing strength of a rivet in double shear is usually about 1.75 times the strength in single shear.



Let d = diameter of rivet	T = tensile strength of plate
t = thickness of plate	C = crushing " " rivet
p = pitch of rivets	S = shearing " " "

All dimensions in inches, and stresses in pounds per square inch.

Lap Joint, Single Riveted

Resistance to tearing plate between rivets $= t\,(p-d)\,T$

" " crushing of one rivet $= t\,d\,C$

" " shearing " " " $= \frac{1}{4}\,\pi\,d^2\,S$

Lap Joint, Double Riveted

Resistance to tearing plate between two rivets $= t\,(p-d)\,T$

" " crushing of two rivets $= 2\,td\,C$

" " shearing " " " $= \dfrac{2\,\pi\,d^2\,S}{4}$

Butt Strap, Single Riveted, Two Cover Plates

Resistance to tearing plate $= t\,(p-d)\,T$

" " crushing of one rivet $= t\,d\,C$

" " shearing " " " $= \dfrac{2\,\pi\,d^2\,S}{4}$

Butt Strap, Double Riveted, Two Cover Plates

Resistance to tearing plate $= t\,(p-d)\,T$

" " crushing of two rivets $= 2\,t\,d\,C$

" " shearing " " " $= \dfrac{4\,\pi\,d^2\,S}{4}$

STRUCTURAL SHAPES

(Rolled by Carnegie Steel Co.)

I = moment of inertia about line through center of gravity

y = distance from center of gravity to extreme fiber

s = section modulus $= \dfrac{I}{y}$. A = area of section

r = radius of gyration $= \sqrt{\dfrac{I}{A}}$.

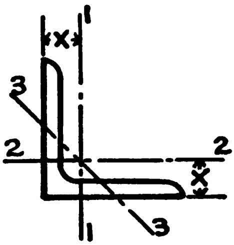
Structural Channels

Section Index	Depth of Channel	Weight per Foot	Area of Section	Width of Flange	Thickness of Web	Axis 1-1			Axis 2-2			
						I	r	s	I	r	s	x
	In.	Lbs.	Sq.ins.	In.	In.	In.^{4}	In.	In.^{3}	In.^{4}	In.	In.^{3}	In.
C 1	15	55.0	16.18	3.818	.818	430.2	5.16	57.4	12.2	.87	4.1	.82
		50.0	14.71	3.720	.720	402.7	5.23	53.7	11.2	.87	3.8	.80
		45.0	13.24	3.622	.622	375.1	5.32	50.0	10.3	.88	3.6	.79
		40.0	11.76	3.524	.524	347.5	5.43	46.3	9.4	.89	3.4	.78
		35.0	10.29	3.426	.426	319.9	5.58	42.7	8.5	.91	3.2	.79
		33.0	9.90	3.400	.400	312.6	5.62	41.7	8.2	.91	3.2	.79
C 2	12	40.0	11.76	3.418	.758	196.9	4.09	32.8	6.6	.75	2.5	.72
		35.0	10.29	3.296	.636	179.3	4.17	29.9	5.9	.76	2.3	.69
		30.0	8.82	3.173	.513	161.7	4.28	26.9	5.2	.77	2.1	.68
		25.0	7.35	3.050	.390	144.0	4.43	24.0	4.5	.79	1.9	.68
		20.5	6.03	2.940	.280	128.1	4.61	21.4	3.9	.81	1.7	.70
C 3	10	35.0	10.29	3.183	.823	115.5	3.35	23.1	4.7	.67	1.9	.70
		30.0	8.82	3.036	.676	103.2	3.42	20.7	4.0	.67	1.7	.65
		25.0	7.35	2.889	.529	91.0	3.52	18.2	3.4	.68	1.5	.62
		20.0	5.88	2.742	.382	78.7	3.66	15.7	2.9	.70	1.3	.61
		15.0	4.46	2.600	.240	66.9	3.87	13.4	2.3	.72	1.2	.64

STRUCTURAL CHANNELS—*Continued*

Section Index	Depth of Channel	Weight per Foot	Area of Section	Width of Flange	Thick-ness of Web	Axis 1-1 I	Axis 1-1 r	Axis 1-1 s	Axis 2-2 I	Axis 2-2 r	Axis 2-2 s	Axis 2-2 x
	In.	Lbs.	Sq.ins.	In.	In.	In.⁴	In.	In.³	In.⁴	In.	In.³	In.
C 4	9	25.0	7.35	2.815	.615	70.7	3.10	15.7	3.0	.64	1.4	.62
		20.0	5.88	2.652	.452	60.8	3.21	13.5	2.5	.65	1.2	.59
		15.0	4.41	2.488	.288	50.9	3.40	11.3	2.0	.67	1.0	.59
		13.25	3.89	2.430	.230	47.3	3.49	10.5	1.8	.67	0.97	.61
C 5	8	21.25	6.25	2.622	.582	47.8	2.77	11.9	2.3	.60	1.1	.59
		18.75	5.51	2.530	.490	43.8	2.82	11.0	2.0	.60	1.0	.57
		16.25	4.78	2.439	.399	39.9	2.89	10.0	1.8	.61	0.95	.56
		13.75	4.04	2.347	.307	36.0	2.98	9.0	1.6	.62	0.87	.56
		11.25	3.35	2.260	.220	32.3	3.11	8.1	1.3	.63	0.79	.58
C 6	7	19.75	5.81	2.513	.633	33.2	2.39	9.5	1.9	.56	0.96	.58
		17.25	5.07	2.408	.528	30.2	2.44	8.6	1.6	.57	0.87	.56
		14.75	4.34	2.303	.423	27.2	2.50	7.8	1.4	.57	0.79	.54
		12.25	3.60	2.198	.318	24.2	2.59	6.9	1.2	.58	0.71	.53
		9.75	2.85	2.090	.210	21.1	2.72	6.0	0.98	.59	0.63	.55
C 7	6	15.5	4.56	2.283	.563	19.5	2.07	6.5	1.3	.53	0.74	.55
		13.0	3.82	2.160	.440	17.3	2.13	5.8	1.1	.53	0.65	.52
		10.5	3.09	2.038	.318	15.1	2.21	5.0	0.88	.53	0.57	.50
		8.0	2.38	1.920	.200	13.0	2.34	4.3	0.70	.54	0.50	.52
C 8	5	11.5	3.38	2.037	.477	10.4	1.75	4.2	0.82	.49	0.54	.51
		9.0	2.65	1.890	.330	8.9	1.83	3.6	0.64	.49	0.45	.48
		6.5	1.95	1.750	.190	7.4	1.95	3.0	0.48	.50	0.38	.49
C 9	4	7.25	2.13	1.725	.325	4.6	1.46	2.3	0.38	.46	0.35	.46
		6.25	1.84	1.652	.252	4.2	1.51	2.1	0.44	.45	0.32	.46
		5.25	1.55	1.580	.180	3.8	1.56	1.9	0.32	.45	0.29	.46
C 72	3	6.0	1.76	1.602	.362	2.1	1.08	1.4	0.31	.42	0.27	.46
		5.0	1.47	1.504	.264	1.8	1.12	1.2	0.25	.42	0.24	.44
		4.0	1.19	1.410	.170	1.6	1.17	1.1	0.20	.41	0.21	.44

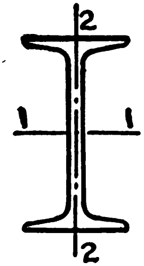
EQUAL ANGLES



Section Index	Size	Weight per Foot	Area of Section	Axis 1-1 and Axis 2-2 I	r	s	x	Axis 3-3 r min.
	Ins.	Pounds	In.²	In.⁴	In.	In.³	In.	In.
A 3	6 x 6 x ¾	28.7	8.44	28.2	1.83	6.7	1.78	1.17
A 4	11/16	26.5	7.78	26.2	1.83	6.2	1.75	1.17
A 5	⅝	24.2	7.11	24.2	1.84	5.7	1.73	1.17
A 6	9/16	21.9	6.43	22.1	1.85	5.1	1.71	1.18
A 7	½	19.6	5.75	19.9	1.86	4.6	1.68	1.18
A 8	7/16	17.2	5.06	17.7	1.87	4.1	1.66	1.19
A 88	⅜	14.9	4.36	15.4	1.88	3.5	1.64	1.19
A 11	5 x 5 x ¾	23.6	6.94	15.7	1.50	4.5	1.52	.97
A 12	11/16	21.8	6.40	14.7	1.51	4.2	1.50	.97
A 13	⅝	20.0	5.86	13.6	1.52	3.9	1.48	.97
A 14	9/16	18.1	5.31	12.4	1.53	3.5	1.46	.98
A 15	½	16.2	4.75	11.3	1.54	3.2	1.43	.98
A 16	7/16	14.3	4.18	10.0	1.55	2.8	1.41	.98
A 17	⅜	12.3	3.61	8.7	1.56	2.4	1.39	.99
A 19	4 x 4 x ¾	18.5	5.44	7.7	1.19	2.8	1.27	.77
A 20	11/16	17.1	5.03	7.2	1.19	2.6	1.25	.77
A 21	⅝	15.7	4.61	6.7	1.20	2.4	1.23	.77
A 22	9/16	14.3	4.18	6.1	1.21	2.2	1.21	.78
A 23	½	12.8	3.75	5.6	1.22	2.0	1.18	.78
A 24	7/16	11.3	3.31	5.0	1.23	1.8	1.16	.78
A 25	⅜	9.8	2.86	4.4	1.23	1.5	1.14	.79
A 29	3½x3½x⅝	13.6	3.98	4.3	1.04	1.8	1.10	.68
A 30	9/16	12.4	3.62	4.0	1.05	1.6	1.08	.68
A 31	½	11.1	3.25	3.6	1.06	1.5	1.06	.68
A 32	7/16	9.8	2.87	3.3	1.07	1.3	1.04	.68
A 33	⅜	8.5	2.48	2.9	1.07	1.2	1.01	.69
A 99	5/16	7.2	2.09	2.5	1.08	.98	.99	.69
A 285	¼	5.8	1.69	2.0	1.09	.79	.97	.69
A 36	3 x 3 x ½	9.4	2.75	2.2	.90	1.1	.93	.58
A 37	7/16	8.3	2.43	2.0	.91	.95	.91	.58
A 38	⅜	7.2	2.11	1.8	.91	.83	.89	.58
A 39	5/16	6.1	1.78	1.5	.92	.71	.87	.59
A 40	¼	4.9	1.44	1.2	.93	.58	.84	.59
A 48	2½x2½x⅜	5.9	1.73	.98	.75	.57	.76	.48
A 49	5/16	5.0	1.47	.85	.76	.48	.74	.49
A 50	¼	4.1	1.19	.70	.77	.39	.72	.49
A 59	2 x 2 x ¼	3.19	.94	.35	.61	.25	.59	.39
A 60	3/16	2.44	.71	.28	.62	.19	.57	.40

Structural Shapes—of steel made by the open hearth process. The steel used in ships has a tensile strength of 58,000–68,000 lbs. per sq. in.; yield point minimum .5 tensile strength; elongation in 8 ins. minimum per cent $\frac{1{,}500{,}000}{\text{tensile strength}}$. Steel for buildings has a slightly lower tensile strength.

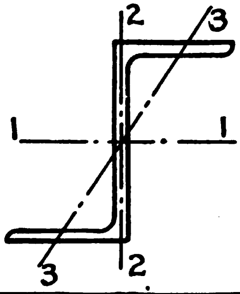
I Beams



Section Index	Depth of Beam	Weight per Foot	Area of Section	Width of Flange	Thickness of Web	Axis 1–1			Axis 2–2		
						I	r	s	I	r	s
	In.	Lbs.	In.^{2}	In.	In.	In.^{4}	In.	In.^{3}	In.^{4}	In.	In.^{3}
B 61	27	90	26.33	9.000	.524	2958.3	10.60	219.1	75.3	1.69	16.7
B 24	24	115	33.98	8.000	.750	2955.5	9.33	246.3	83.2	1.57	20.8
		110	32.48	7.938	.688	2883.5	9.42	240.3	81.0	1.58	20.4
		105	30.98	7.875	.625	2811.5	9.53	234.3	78.9	1.60	20.0
B 1	24	100	29.41	7.254	.754	2379.6	9.00	198.3	48.6	1.23	13.4
		95	27.94	7.193	.693	2309.0	9.09	192.4	47.1	1.30	13.1
		90	26.47	7.131	.631	2238.4	9.20	186.5	45.7	1.31	12.8
		85	25.00	7.070	.570	2167.8	9.31	180.7	44.4	1.33	12.6
		80	23.32	7.000	.500	2087.2	9.46	173.9	42.9	1.36	12.3
B 62	24	74	21.70	9.000	.476	1950.1	9.48	162.5	61.2	1.68	13.6
B 63	21	60.5	17.68	8.250	.428	1235.5	8.36	117.7	43.5	1.57	10.6
B 2	20	100	29.41	7.284	.884	1655.6	7.50	165.6	52.7	1.34	14.5
		95	27.94	7.210	.810	1606.6	7.58	160.7	50.8	1.35	14.1
		90	26.47	7.137	.737	1557.6	7.67	155.8	49.0	1.36	13.7
		85	25.00	7.063	.663	1508.5	7.77	150.9	47.3	1.37	13.4
		80	23.73	7.000	.600	1466.3	7.86	146.6	45.8	1.39	13.1
B 3	20	75	22.06	6.399	.649	1268.8	7.58	126.9	30.3	1.17	9.5
		70	20.59	6.325	.575	1219.8	7.70	122.0	29.0	1.19	9.2
		65	19.08	6.250	.500	1169.5	7.83	117.0	27.9	1.21	8.9
B 81	18	90	26.47	7.245	.807	1260.4	6.90	140.0	52.0	1.40	14.4
		85	25.00	7.162	.725	1220.7	6.99	135.6	50.0	1.42	14.0
		80	23.53	7.083	.644	1181.0	7.09	131.2	48.1	1.43	13.6
		75	22.05	7.000	.562	1141.3	7.19	126.8	46.2	1.45	13.2
B 80	18	70	20.59	6.259	.719	921.2	6.69	102.4	24.6	1.09	7.9
		65	19.12	6.177	.637	881.5	6.79	97.9	23.5	1.11	7.6
		60	17.65	6.095	.555	841.8	6.91	93.5	22.4	1.13	7.3
		55	15.93	6.000	.460	795.6	7.07	88.4	21.2	1.15	7.1
B 64	18	48	14.08	7.500	.380	737.1	7.23	81.9	30.0	1.46	8.0
B 5	15	75	22.06	6.292	.882	691.2	5.60	92.2	30.7	1.18	9.8
		70	20.59	6.194	.784	663.7	5.68	88.5	29.0	1.19	9.4
		65	19.12	6.096	.686	636.1	5.77	84.8	27.4	1.20	9.0
		60	17.67	6.000	.590	609.0	5.87	81.2	26.0	1.21	8.7

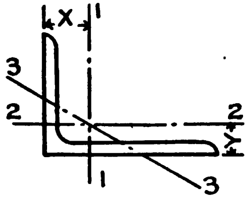
Section Index	Depth of Beam	Weight per Foot	Area of Section	Width of Flange	Thickness of Web	Axis 1-1			Axis 2-2		
						I	r	s	I	r	s
	In.	Lbs.	In.^{2}	In.	In.	In.^{4}	In.	In.^{3}	In.^{4}	In.	In.^{3}
B 7	15	55	16.18	5.746	.656	511.0	5.62	68.1	17.1	1.02	5.9
		50	14.71	5.648	.558	483.4	5.73	64.5	16.0	1.04	5.7
		45	13.24	5.550	.460	455.9	5.87	60.8	15.1	1.07	5.4
		42	12.48	5.500	.410	441.8	5.95	58.9	14.6	1.08	5.3
B 65	15	37.5	10.91	6.750	.332	405.5	6.10	54.1	19.9	1.35	5.9
B 8	12	55	16.18	5.611	.821	321.0	4.45	53.5	17.5	1.04	6.2
		50	14.71	5.489	.699	303.4	4.54	50.6	16.1	1.05	5.9
		45	13.24	5.366	.576	285.7	4.65	47.6	14.9	1.06	5.6
		40	11.84	5.250	.460	269.0	4.77	44.8	13.8	1.08	5.3
B 9	12	35	10.29	5.086	.436	228.3	4.71	38.0	10.1	.99	4.0
		31.5	9.26	5.000	.350	215.8	4.83	36.0	9.5	1.01	3.8
B 66	12	28	8.15	6.000	.284	199.4	4.95	33.2	12.6	1.24	4.2
B 11	10	40	11.76	5.099	.749	158.7	3.67	31.7	9.5	.90	3.7
		35	10.29	4.952	.602	146.4	3.77	29.3	8.5	.91	3.4
		30	8.82	4.805	.455	134.2	3.90	26.8	7.7	.93	3.2
		25	7.37	4.660	.310	122.1	4.07	24.4	6.9	.97	3.0
B 67	10	22.25	6.54	5.500	.252	113.6	4.17	22.7	9.0	1.17	3.3
B 13	9	35	10.29	4.772	.732	111.8	3.29	24.8	7.3	.84	3.1
		30	8.82	4.609	.569	101.9	3.40	22.6	6.4	.85	2.8
		25	7.35	4.446	.406	91.9	3.54	20.4	5.7	.88	2.5
		21	6.31	4.330	.290	84.9	3.67	18.9	5.2	.90	2.4
B 15	8	25.5	7.50	4.271	.541	68.4	3.02	17.1	4.8	.80	2.2
		23	6.76	4.179	.449	64.5	3.09	16.1	4.4	.81	2.1
		20.5	6.03	4.087	.357	60.6	3.17	15.2	4.1	.82	2.0
		18	5.33	4.000	.270	56.9	3.27	14.2	3.8	.84	1.9
B 68	8	17.5	5.12	5.000	.220	58.4	3.38	14.6	6.2	1.10	2.5
B 17	7	20	5.88	3.868	.458	42.2	2.68	12.1	3.2	.74	1.7
		17.5	5.15	3.763	.353	39.2	2.76	11.2	2.9	.76	1.6
		15	4.42	3.660	.250	36.2	2.86	10.4	2.7	.78	1.5
B 19	6	17.25	5.07	3.575	.475	26.2	2.27	8.7	2.4	.68	1.3
		14.75	4.34	3.452	.352	24.0	2.35	8.0	2.1	.69	1.2
		12.25	3.61	3.330	.230	21.8	2.46	7.3	1.9	.72	1.1
B 21	5	14.75	4.34	3.294	.504	15.2	1.87	6.1	1.7	.63	1.0
		12.25	3.60	3.147	.357	13.6	1.94	5.5	1.5	.63	.92
		9.75	2.87	3.000	.210	12.1	2.05	4.8	1.2	.65	.82
B 23	4	10.5	3.09	2.880	.410	7.1	1.52	3.6	1.0	.57	.70
		9.5	2.79	2.807	.337	6.8	1.55	3.4	.93	.58	.66
		8.5	2.50	2.733	.263	6.4	1.59	3.2	.85	.58	.62
		7.5	2.21	2.660	.190	6.0	1.64	3.0	.77	.59	.58
B 77	3	7.5	2.21	2.521	.361	2.9	1.15	1.9	.60	.52	.48
		6.5	1.91	2.423	.263	2.7	1.19	1.8	.53	.52	.44
		5.5	1.63	2.330	.170	2.5	1.23	1.7	.46	.53	.40

Zees



Section Index	Size: Depth	Size: Flanges	Size: Thickness	W'ght. per Foot	Area of Section	Axis 1-1: I	Axis 1-1: r	Axis 1-1: s	Axis 2-2: I	Axis 2-2: r	Axis 2-2: s	Axis 3-3: r min.
	In.	In.	In.	Lbs.	In.²	In.⁴	In.	In.³	In.⁴	In.	In.³	In.
Z 3	6 1/8	3 5/8	7/8	34.6	10.17	50.2	2.22	16.4	19.2	1.37	6.0	.83
	6 1/16	3 9/16	13/16	32.0	9.40	46.1	2.22	15.2	17.3	1.36	5.5	.82
	6	3 1/2	3/4	29.4	8.63	42.1	2.21	14.0	15.4	1.34	4.9	.81
Z 2	6 1/8	3 5/8	11/16	28.1	8.25	43.2	2.29	14.1	16.3	1.41	5.0	.84
	6 1/16	3 9/16	5/8	25.4	7.46	38.9	2.28	12.8	14.4	1.39	4.4	.82
	6	3 1/2	9/16	22.8	6.68	34.6	2.28	11.5	12.6	1.37	3.9	.81
Z 1	6 1/8	3 5/8	1/2	21.1	6.19	34.4	2.36	11.2	12.9	1.44	3.8	.84
	6 1/16	3 9/16	7/16	18.4	5.39	29.8	2.35	9.8	11.0	1.43	3.3	.83
	6	3 1/2	3/8	15.7	4.59	25.3	2.35	8.4	9.1	1.41	2.8	.83
Z 6	5 1/8	3 3/8	13/16	28.4	8.33	28.7	1.86	11.2	14.4	1.31	4.8	.76
	5 1/16	3 5/16	3/4	26.0	7.64	26.2	1.85	10.3	12.8	1.30	4.4	.74
	5	3 1/4	11/16	23.7	9.96	23.7	1.84	9.5	11.4	1.28	3.9	.73
Z 5	5 1/8	3 3/8	5/8	22.6	6.64	24.5	1.92	9.6	12.1	1.35	3.9	.76
	5 1/16	3 5/16	9/16	20.2	5.94	21.8	1.91	8.6	10.5	1.33	3.5	.75
	5	3 1/4	1/2	17.9	5.25	19.2	1.91	7.7	9.1	1.31	3.0	.74
Z 4	5 1/8	3 3/8	7/16	16.4	4.81	19.1	1.99	7.4	9.2	1.38	2.9	.77
	5 1/16	3 5/16	3/8	14.0	4.10	16.2	1.99	6.4	7.7	1.37	2.5	.76
	5	3 1/4	5/16	11.6	3.40	13.4	1.98	5.3	6.2	1.35	2.0	.75
Z 9	4 1/8	3 3/16	3/4	23.0	6.75	15.0	1.49	7.3	11.2	1.29	4.0	.68
	4 1/16	3 1/8	11/16	20.9	6.14	13.5	1.48	6.7	10.0	1.27	3.6	.67
	4	3 1/16	5/8	18.9	5.55	12.1	1.48	6.1	8.7	1.25	3.2	.66
Z 8	4 1/8	3 3/16	9/16	18.0	5.27	12.7	1.55	6.2	9.3	1.33	3.2	.68
	4 1/16	3 1/8	1/2	15.9	4.66	11.2	1.55	5.5	8.0	1.31	2.8	.67
	4	3 1/16	7/16	13.8	4.05	9.7	1.55	4.8	6.7	1.29	2.4	.66
Z 7	4 1/8	3 3/16	3/8	12.5	3.66	9.6	1.62	4.7	6.8	1.36	2.3	.69
	4 1/16	3 1/8	5/16	10.3	3.03	7.9	1.62	3.9	5.5	1.34	1.8	.68
	4	3 1/16	1/4	8.2	2.41	6.3	1.62	3.1	4.2	1.33	1.4	.67
Z 12	3 1/16	2 3/4	9/16	14.3	4.18	5.3	1.12	3.4	5.7	1.17	2.3	.54
	3	2 11/16	1/2	12.6	3.69	4.6	1.12	3.1	4.9	1.15	2.0	.53
Z 11	3 1/16	2 3/4	7/16	11.5	3.36	4.6	1.17	3.0	4.8	1.19	1.9	.55
	3	2 11/16	3/8	9.8	2.86	3.9	1.16	2.6	3.9	1.17	1.6	.54
Z 10	3 1/16	2 3/4	5/16	8.5	2.48	3.6	1.21	2.4	3.6	1.21	1.4	.56
	3	2 11/16	1/4	6.7	1.97	2.9	1.21	1.9	2.8	1.19	1.1	.55

Unequal Angles



Section Index	Size	Weight per Foot	Area of section	Axis 1-1				Axis 2-2				Axis 3-3
				I	r	s	x	I	r	s	x	r min.
	Ins.	Pounds	In.²	In.⁴	In.	In.³	In.	In.⁴	In.	In.³	In.	In.
A 171	6x3½x¾	22.4	6.56	23.3	1.89	6.1	2.18	5.8	.94	2.3	.93	.75
A 172	11/16	20.6	6.06	21.7	1.89	5.6	2.15	5.5	.95	2.1	.90	.75
A 173	5/8	18.9	5.55	20.1	1.90	5.2	2.13	5.1	.96	1.9	.88	.75
A 174	9/16	17.1	5.03	18.4	1.91	4.7	2.11	4.7	.96	1.8	.86	.75
A 175	½	15.3	4.50	16.6	1.92	4.2	2.08	4.3	.97	1.6	.83	.76
A 176	7/16	13.5	3.97	14.8	1.93	3.7	2.06	3.8	.98	1.4	.81	.76
A 177	⅜	11.7	3.42	12.9	1.94	3.3	2.04	3.3	.99	1.2	.79	.77
A 201	5 x 3 x ½	12.8	3.75	9.5	1.59	2.9	1.75	2.6	.83	1.1	.75	.65
A 202	7/16	11.3	3.31	8.4	1.60	2.6	1.73	2.3	.84	1.0	.73	.65
A 203	⅜	9.8	2.86	7.4	1.61	2.2	1.70	2.0	.84	.89	.70	.65
A 280	5/16	8.2	2.40	6.3	1.61	1.9	1.68	1.8	.85	.75	.68	.66
A 225	4 x 3 x ½	11.1	3.25	5.0	1.25	1.9	1.33	2.4	.86	1.1	.83	.64
A 226	7/16	9.8	2.87	4.5	1.25	1.7	1.30	2.2	.87	1.0	.80	.64
A 227	⅜	8.5	2.48	4.0	1.26	1.5	1.28	1.9	.88	.87	.78	.64
A 228	5/16	7.2	2.09	3.4	1.27	1.2	1.26	1.7	.89	.74	.76	.65
A 234	3½x3x½	10.2	3.00	3.5	1.07	1.5	1.13	2.3	.88	1.1	.88	.62
A 235	7/16	9.1	2.65	3.1	1.08	1.3	1.10	2.1	.89	.98	.85	.62
A 236	⅜	7.9	2.30	2.7	1.09	1.1	1.08	1.8	.90	.85	.83	.62
A 237	5/16	6.6	1.93	2.3	1.10	.96	1.06	1.6	.90	.72	.81	.63
A 286	¼	5.4	1.56	1.9	1.11	.78	1.04	1.3	.91	.58	.79	.63
A 255	3x2½x⅜	6.6	1.92	1.7	.93	.81	.96	1.0	.74	.58	.71	.52
A 256	5/16	5.6	1.62	1.4	.94	.69	.93	.90	.74	.49	.68	.53
A 257	¼	4.5	1.31	1.2	.95	.56	.91	.74	.75	.40	.66	.53

Ordering Shapes.—Beams, channels, bulb angles, Tees and Zees should be ordered to weight per linear foot. Angles may be ordered either to weight per foot or to thickness, but never both.

WIRE AND SHEET METAL GAUGES

DIAMETERS AND THICKNESSES IN DECIMAL PARTS OF AN INCH

Gauge number	Am. wire gauge or Brown & Sharpe	Birmingham wire gauge (B. W. G.) or Stubs	Steel wire gauge or Washburn & Moen or Roebling	Trenton Iron Co.	Stubs' steel wire	U. S. Standard for sheet metal	Imperial wire or N. B. S.
000000	.....	....	.....	.....	....	.4687	.464
00000	.....	....	.....	.4500	....	.4375	.432
0000	.4600	.454	.3938	.4000	....	.4062	.400
000	.4096	.425	.3625	.3600	....	.3750	.372
00	.3648	.380	.3310	.3300	....	.3437	.348
0	.3249	.340	.3065	.3050	....	.3125	.324
1	.2893	.300	.2830	.2850	.227	.2812	.300
2	.2576	.284	.2625	.2650	.219	.2656	.276
3	.2294	.259	.2437	.2450	.212	.2500	.252
4	.2043	.238	.2253	.2250	.207	.2344	.232
5	.1819	.220	.2070	.2050	.204	.2187	.212
6	.1620	.203	.1920	.1900	.201	.2031	.192
7	.1443	.180	.1770	.1750	.199	.1875	.177
8	.1285	.165	.1620	.1600	.197	.1719	.160
9	.1144	.148	.1483	.1450	.194	.1562	.144
10	.1019	.134	.1350	.1300	.191	.1406	.128
11	.0907	.120	.1205	.1175	.188	.1250	.116
12	.0808	.109	.1055	.1050	.185	.1094	.104
13	.0720	.095	.0915	.0925	.182	.0937	.092
14	.0641	.083	.0800	.0800	.180	.0781	.080
15	.0571	.072	.0720	.0700	.178	.0703	.072
16	.0508	.065	.0625	.0610	.175	.0625	.064
17	.0453	.058	.0540	.0525	.172	.0562	.056
18	.0403	.049	.0475	.0450	.168	.0500	.048
19	.0359	.042	.0410	.0400	.164	.0437	.040
20	.0320	.035	.0348	.0350	.161	.0375	.036
21	.0285	.032	.0317	.0310	.157	.0344	.032
22	.0253	.028	.0286	.0280	.155	.0312	.028
23	.0226	.025	.0258	.0250	.153	.0281	.024
24	.0201	.022	.0230	.0225	.151	.0250	.022
25	.0179	.020	.0204	.0200	.148	.0219	.020
26	.0159	.018	.0181	.0180	.146	.0187	.018
27	.0142	.016	.0173	.0170	.143	.0172	.0164
28	.0126	.014	.0162	.0160	.139	.0156	.0148
29	.0113	.013	.0150	.0150	.134	.0141	.0136
30	.0100	.012	.0140	.0140	.127	.0125	.0124
31	.0089	.010	.0132	.0130	.120	.0109	.0116
32	.0079	.009	.0128	.0120	.115	.0102	.0108
33	.0071	.008	.0118	.0110	.112	.0094	.0100

Gauge number	Am. wire gauge or Brown & Sharpe	Birmingham wire gauge (B. W. G.) or Stubs.	Steel wire gauge or Washburn & Moen or Roebling	Trenton Iron Co.	Stubs' steel wire	U. S. Standard for sheet metal	Imperial wire or N. B. S.
34	.0063	.007	.0104	.0100	.110	.0086	.0092
35	.0056	.005	.0095	.0095	.108	.0078	.0084
36	.0050	.004	.0090	.0090	.106	.0070	.0076
37	.0045	....	.....	.0085	.103	.0066	.0068
38	.0040	....	.....	.0080	.101	.0062	.0060
39	.0035	....	.....	.0075	.099	.....	.0052
40	.0031	....	.....	.0070	.097	.....	.0048

WEIGHT OF FLAT BAR STEEL, PER LINEAL FOOT

Size	½	⅝	¾	⅞	1	1⅛	1¼	1⅜	1½	1¾	2	2¼	2½	2¾	3	3½
⅛	.213	.266	.320	.372	.426	.479	.530	.585	.640	.745	.850	.955	1.07	1.18	1.28	1.49
3/16	.319	.399	.480	.558	.639	.718	.790	.878	.960	1.12	1.28	1.43	1.60	1.76	1.92	2.24
¼	.425	.533	.640	.743	.852	.958	1.06	1.17	1.28	1.49	1.70	1.91	2.13	2.34	2.56	2.98
5/16	.531	.665	.800	.929	1.06	1.20	1.33	1.46	1.60	1.86	2.13	2.39	2.66	2.92	3.19	3.72
⅜	.638	.798	.960	1.12	1.28	1.43	1.59	1.75	1.91	2.23	2.55	2.87	3.20	3.51	3.83	4.46
7/16	.744	.931	1.12	1.30	1.49	1.67	1.86	2.05	2.23	2.60	2.98	3.35	3.72	4.09	4.46	5.21
½	....	1.07	1.28	1.49	1.70	1.91	2.13	2.34	2.55	2.98	3.40	3.83	4.26	4.68	5.10	5.96
9/16	....	1.20	1.44	1.67	1.91	2.15	2.39	2.63	2.87	3.35	3.83	4.30	4.78	5.26	5.74	6.69
⅝	....	....	1.60	1.86	2.12	2.39	2.66	2.92	3.19	3.72	4.26	4.79	5.32	5.86	6.39	7.44
11/16	....	....	1.76	2.04	2.34	2.63	2.92	3.22	3.51	4.09	4.68	5.26	5.84	6.43	7.01	8.18
¾	....	....	....	2.23	2.55	2.86	3.19	3.50	3.83	4.46	5.10	5.74	6.40	7.02	7.65	8.92
13/16	....	....	....	2.41	2.76	3.11	3.45	3.80	4.14	4.83	5.53	6.22	6.91	7.60	8.29	9.67
⅞	....	....	....	....	2.98	3.34	3.72	4.09	4.46	5.21	5.96	6.70	7.46	8.19	8.94	10.42
15/16	....	....	....	....	3.19	3.59	3.98	4.38	4.78	5.58	6.38	7.17	7.97	8.77	9.56	11.20
1	....	....	....	....	....	3.82	4.25	4.68	5.10	5.96	6.80	7.66	8.52	9.36	10.20	11.92

WEIGHTS OF STEEL PLATES

Thickness Ins.	Weight per Sq. Ft. Lbs.	Thickness Ins.	Weight per Sq. Ft. Lbs.	Thickness Ins.	Weight per Sq. Ft. Lbs.
¼	10.200	17/32	21.675	13/16	33.150
9/32	11.475	9/16	22.950	27/32	34.425
5/16	12.750	19/32	24.225	⅞	35.700
11/32	14.025	⅝	25.500	29/32	36.975
⅜	15.300	21/32	26.775	15/16	38.250
13/32	16.575	11/16	28.050	31/32	39.525
7/16	17.850	23/32	29.325	1	40.800
15/32	19.125	¾	30.600	....	....
½	20.400	25/32	31.875	....	....

GAUGES FOR PUNCHING

As punching injures the metal around the hole, the hole should be punched $\frac{1}{16}$ in. smaller than the rivet and then reamed, the finished hole being about $\frac{1}{16}$ in. greater than the diameter of the rivet. The burr caused by punching must be removed before the parts are riveted together.

Drilled holes are $\frac{1}{16}$ in. larger than the bolt or rivet. When holes are drilled, the metal is not injured as in punching. For boilers the plates are drilled, as they are also in many cases for tanks.

I BEAMS

Depth of beam	Gage G	Max. rivet in flange	Depth of beam	Gage G	Max. rivet in flange
27	4	7/8	9	2½	¾
24	4	7/8	8	2¼	¾
21	4	7/8	7	2¼	5/8
20	4	7/8	6	2	5/8
18	3¾	7/8	5	1¾	½
15	3½	¾	4	1½	½
12	3	¾	......	.....	.....
10	2¾	¾	......	.....	.....

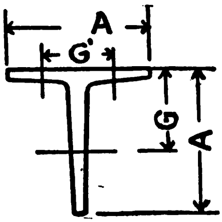
The spacing of the rivets longitudinally in structural shapes depends on the loads to be carried. In ship work the rivet spacing in frames, beams and stiffeners is given in the classification rules (Lloyds or American Bureau of Shipping) under which the ship is built.

For spacing in riveted joints see page 276.

CHANNELS

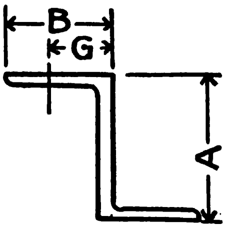
Depth of channel	and weight	Gage G	Max. rivet in flange	Depth of channel	and weight	Gage G	Max. rivet in flange
15	50–55 lb.	2½	⅞	8	16.25–21.25	1½	¾
	33–45 lb.	2			11.25–13.75	1⅜	
13	40–45 lb.	2¾		7	17.25–19.75	1½	
	32–37	2½	⅞		9.75–14.75	1¼	⅝
12	35–40	2		6	13 –15.5	1⅜	
	20.5–30	1¾	⅞		8 –10.5	1⅛	⅝
10	25 to 35	1¾			....	...	....
	15 to 20	1½	¾		....	...	....
9	20 to 25	1½	¾		....	...	....
	13.25 to 15	1⅜			....	...	....

[Carnegie Steel Co., Pittsburgh, Pa.]



TEES

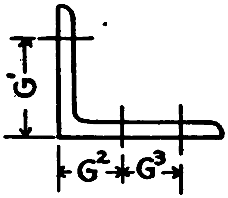
A	G	G′	A	G	G′
4	2¼	2	2¼	1¼	1⅛
3½	2	1¾	2	1⅛	1
2¾	1⅞	1⅜	1½	¾	¾
2½	1⅜	1¼	...	...	...



ZEES

A	B	G	A	B	G
6	3½	2	4	3	1¾
5	3¼	1¾	3	2¾	1½

Angles



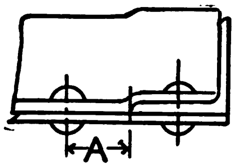
Leg	8	7	6	5	4	3½	3	2½	2	1¾	1½	1⅜	1¼	1	¾
G^1	4½	4	3½	3	2½	2	1¾	1⅜	1⅛	1	⅞	⅞	¾	⅝	½
G^2	3	2½	2½	2	...	...	...	...	...	...	...	...	...	..	..
G^3	3	3	2¼	1¾	...	...	...	...	...	...	...	...	...	..	..
Max. rivet	1⅛	1	⅞	⅞	⅞	⅞	⅞	¾	⅝	½	⅜	⅜	⅜	¼	¼

For column details 6″ leg (½ inch thick or less) against column shaft G^2 = 1¾″, G^3 = 3″.

For diagonal angles, etc., gauge in middle, where riveted leg equals or exceeds 3″ for ¾″ rivets, 3½″ for ⅞″ rivets.

RIVET SPACING

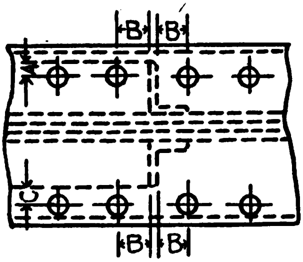
Rivets in Crimped Angles



Distance A should never be less than 2 ins. This applies to button, pan and countersunk head rivets, and also whether angles are watertight or non-watertight.

See also pages 276 and 286.

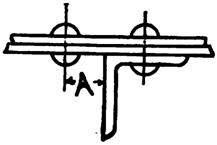
Clearance for Cover Plate Riveting



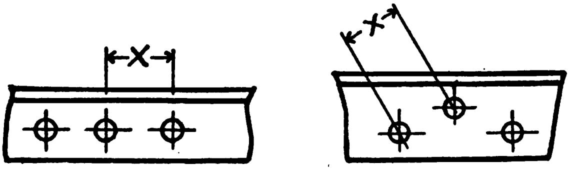
A....	½	1	1½	2	2½	3	3½	4	4½	5	5½	6
B....	2½	2⅝	2¾	2¾	2⅞	2⅞	3	3⅛	3⅛	3¼	3¼	3⅜
C....	0	½	1	2	2	2½	....	....	....	....	....	....

Clearance for Web Riveting

Minimum A	Standard A
⅞″	1⅛″ for ⅝″ rivets
1	1¼ " ¾ "
1⅛	1⅜ " ⅞ "
1¼	1½ " 1 "
1⅜	1⅝ " 1⅛ "



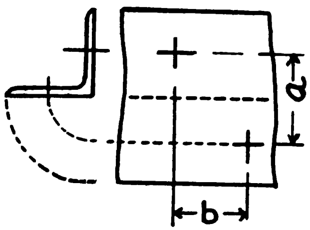
Minimum Rivet Spacing

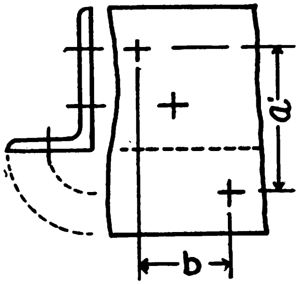


Dia. of rivet.......	¼	⅜	½	⅝	¾	⅞	1	1⅛
X minimum.......	1	1¼	1¾	2	2¼	2⅝	3	3⅜

Stagger of Rivets to Maintain Net Section

Am. Bridge Co.—Standard





One hole out — Two holes out

a = sum of gauges minus thickness of angle.

y = diameter of rivet + 1/8

$a - y = \sqrt{a^2 + b^2} - 2y$ — $a^1 - 2y = \sqrt{a^2 + b^2} - 3y$

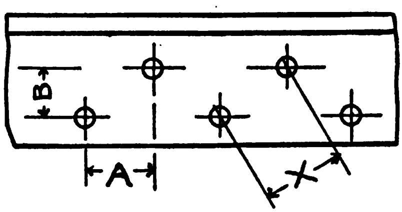
$b = \sqrt{2ay + y^2}$ — $b = \sqrt{2ay + y^2}$

Dimensions in inches

a	3/4" Rivet b	7/8" Rivet b	a^1	3/4" Rivet b	7/8" Rivet b
1	1 5/8	1 3/4	5	3 1/16	3 5/16
1 1/2	1 7/8	2	5 1/2	3 1/4	3 1/2
2	2 1/16	2 1/4	6	3 3/8	3 5/8
2 1/2	2 1/4	2 7/16	6 1/2	3 1/2	3 3/4
3	2 7/16	2 5/8	7	3 5/8	3 7/8
3 1/2	2 9/16	2 13/16	7 1/2	3 3/4	4
4	2 13/16	3	8	3 7/8	4 1/8
4 1/2	2 15/16	3 3/16	8 1/2	4	4 1/4

5/8" rivets can be taken at 1/8" less than for 3/4", and 1" rivets at 1/8" more than for 7/8"

Distance Center to Center of Staggered Rivets



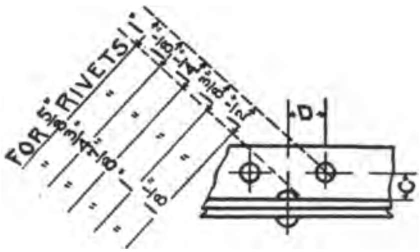
All dimensions in inches

Values of X for varying values of A and B

Value of A	Values of B													
	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	2	2 1/8	2 1/4	2 3/8	2 1/2
1 1/8	1 7/16	1 1/2	1 9/16	1 11/16	1 3/4	1 7/8	2	2 1/16	2 3/16	2 5/16	2 3/8	2 1/2	2 5/8	2 3/4
1 1/4	1 9/16	1 5/8	1 11/16	1 3/4	1 7/8	1 15/16	2 1/16	2 1/8	2 1/4	2 3/8	2 7/16	2 9/16	2 11/16	2 13/16
1 3/8	1 5/8	1 11/16	1 3/4	1 7/8	1 15/16	2	2 1/8	2 3/16	2 5/16	2 7/16	2 1/2	2 5/8	2 3/4	2 7/8
1 1/2	1 3/4	1 13/16	1 7/8	1 15/16	2	2 1/8	2 3/16	2 5/16	2 3/8	2 1/2	2 5/8	2 11/16	2 13/16	2 15/16
1 5/8	1 7/8	1 7/8	2	2 1/16	2 1/8	2 3/16	2 5/16	2 3/8	2 1/2	2 9/16	2 11/16	2 3/4	2 7/8	3
1 3/4	1 15/16	2	2 1/16	2 1/8	2 3/16	2 5/16	2 3/8	2 7/16	2 9/16	2 5/8	2 3/4	2 7/8	2 15/16	3 1/16
1 7/8	2 1/16	2 1/8	2 3/16	2 1/4	2 5/16	2 3/8	2 1/2	2 9/16	2 5/8	2 3/4	2 13/16	2 15/16	3	3 1/8
2	2 3/16	2 1/4	2 5/16	2 3/8	2 7/16	2 1/2	2 9/16	2 5/8	2 3/4	2 13/16	2 15/16	3	3 1/8	3 3/16
2 1/8	2 5/16	2 5/16	2 3/8	2 7/16	2 1/2	2 5/8	2 11/16	2 3/4	2 13/16	2 15/16	3	3 1/16	3 3/16	3 1/4
2 1/4	2 7/16	2 7/16	2 1/2	2 9/16	2 5/8	2 11/16	2 3/4	2 7/8	2 15/16	3	3 1/16	3 3/16	3 1/4	3 3/8
2 3/8	2 1/2	2 9/16	2 5/8	2 11/16	2 3/4	2 13/16	2 7/8	2 15/16	3	3 1/8	3 3/16	3 1/4	3 3/8	3 7/16
2 1/2	2 5/8	2 11/16	2 3/4	2 13/16	2 7/8	2 15/16	3	3 1/16	3 1/8	3 3/16	3 1/4	3 3/8	3 7/16	3 9/16

NOTE—Values below or to right of upper zigzag lines are large enough for 3/4" rivets.
" " " " " lower " " " " " " 7/8" "

Minimum Stagger for Rivets

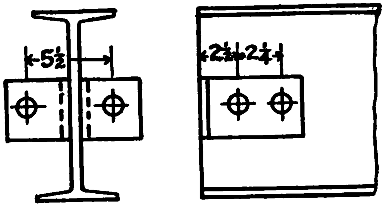


Dia. of Rivet	Minimum stagger D, ins.															
	C, ins.															
	1 1/8	1 3/16	1 1/4	1 5/16	1 3/8	1 7/16	1 1/2	1 9/16	1 5/8	1 11/16	1 3/4	1 13/16	1 7/8	1 15/16	2 1/16	2 3/16
5/8	15/16	7/8	13/16	11/16	1/2	5/16										
3/4	1 1/4	1 3/16	1 1/8	1 1/16	15/16	7/8	3/4	9/16	3/8							
7/8	1 1/2	1 7/16	1 3/8	1 5/16	1 1/4	1 3/16	1 1/8	1	15/16	13/16	5/8	7/16				
1	1 13/16	1 3/4	1 11/16	1 5/8	1 9/16	1 1/2	1 7/16	1 3/8	1 5/16	1 3/16	1 1/8	1	7/8	3/4		
1 1/8	2 1/16	2	1 15/16	1 15/16	1 7/8	1 13/16	1 3/4	1 11/16	1 5/8	1 9/16	1 1/2	1 3/8	1 5/16	1 1/4	1	11/16

BEAM CONNECTIONS

5", 6" and 7" beams

2 angles 6" × 4" × 3/8" × 3", wt. 7 lbs.



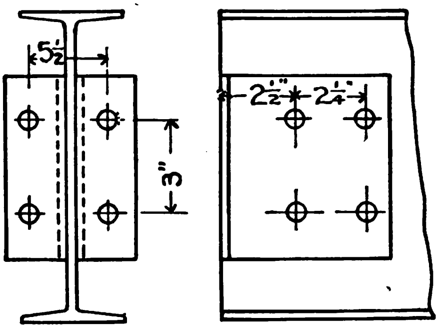
12" I beam connections two angles 4" × 4" × 7/16" × 8½" wt. 17 lbs., 3 rivets 3" pitch

15", 18", 20" beam connections two angles 4" × 4" × 7/16" × 11½" wt. 23 lbs., 4 rivets 3" pitch

21" beam connections two angles 4" × 4" × ½" × 1"—2½" wt. 33 lbs., 5 rivets 3" pitch

8", 9" and 10" beams

2 angles 6" × 4" × 3/8" × 5½", wt. 13 lbs.



24" beam connections two angles 4" × 4" × ½" × 1"—5½" wt. 39 lbs., 6 rivets 3" pitch

27" beam connections two angles 4" × 4" × ½" × 1"—8½" wt. 46 lbs., 7 rivets 3" pitch

Rivets and bolts ¾" diameter

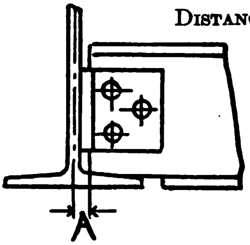
Weights given are for ¾" shop rivets and angle connections, about 20% should be added for field rivets or bolts.

Limiting Values of Beam Connections

I Beams		Value of web connection	Values of outstanding legs of connection angles					
			Field rivets			Field bolts		
Depth ins.	Weight lbs. per ft.	Shop rivets in enclosed bearing lbs.	¾ in. rivets or turned bolts single shear lbs.	Minimum allowable span in ft. uniform load	t in.	¾ in. rough bolts single shear lbs.	Minimum allowable span in ft. uniform load	t in.
27	90	82530	61900	18.9	⅝	49500	23.6	⅝
24	80	67500	53000	17.5	⅝	42400	21.9	⅝
21	60½	48150	44200	14.2	⅝	35300	17.8	⅝
20	65	45000	35300	17.6	⅝	28300	22.1	⅝
18	55	41400	35300	13.3	⅝	28300	16.7	⅝
15	42	36900	35300	8.9	⅝	28300	11.1	⅝
12	31½	23600	26500	8.1	9/16	21200	9.0	⅝
10	25	27900	17700	7.4	⅝	14100	9.2	⅝
9	21	26100	17700	5.7	⅝	14100	7.1	⅝
8	18	24300	17700	4.3	⅝	14100	5.4	⅝
7	15	11300	8800	6.2	⅝	7100	7.8	⅝
6	12¼	10400	8800	4.4	⅝	7100	5.5	⅝
5	9¾	9500	8800	2.9	⅝	7100	3.6	⅝

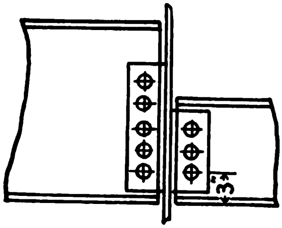
t = web thickness in bearing to develop max. allowable reactions when beams frame opposite. [Pocket Companion, Carnegie Steel Co.]

Distance Between Beams

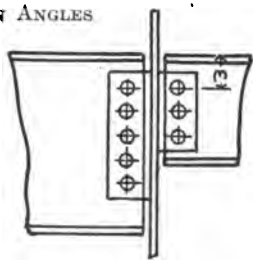


A = ½ thickness of web + 1/16″

Location of Connection Angles



FLUSH BOTTOM



FLUSH TOP

SECTION VIII

USEFUL TABLES

WEIGHTS AND MEASURES — METRIC SYSTEM — METRIC AND U. S. EQUIVALENT MEASURES—DECIMAL EQUIVALENTS OF AN INCH—INCHES AND FRACTIONS IN DECIMALS OF A FOOT—STRENGTH OF MATERIALS—SPECIFIC GRAVITIES AND WEIGHTS OF MATERIALS—EQUIVALENT VALUES OF ELECTRICAL, MECHANICAL AND HEAT UNITS

WEIGHTS AND MEASURES
(United States and Great Britain)

Troy Weight

24 grains	= 1 pennyweight (pwt.)
20 pwts.	= 1 ounce
12 ounces	= 1 pound

Apothecaries' Weight

20 grains	= 1 scruple	8 drams	= 1 ounce
3 scruples	= 1 dram	12 ounces	= 1 pound

Avoirdupois Weight

16 drams	=1 ounce	2000 pounds	= 1 short ton
16 ounces	= 1 pound	2240 pounds	= 1 long ton

Shipping Weight

16 ounces = 1 pound
28 pounds = 1 quarter
4 quarters or 112 pounds = 1 hundredweight (cwt.)
20 cwt. / 2240 pounds } = 1 ton.

Linear Measure (Land)

12 inches	= 1 foot	40 rods	= 1 furlong
3 feet	= 1 yard	8 furlongs or 5280 ft.	= 1 mile
5½ yards	= 1 rod		

Linear Measure (Nautical)

6 feet	= 1 fathom	6080 feet	= 1 nautical mile or knot
120 fathoms	= 1 cable length	3 knots	= 1 league

Square Measure

144 square inches	= 1 square foot	40 square rods	= 1 rood
9 square feet	= 1 square yard	4 roods	= 1 acre
$30\frac{1}{4}$ square yards	= 1 square rod	640 acres	= 1 square mile

Time Measure

60 seconds	= 1 minute	24 hours	= 1 day
60 minutes	= 1 hour	7 days	= 1 week

28, 29, 30 or 31 days = 1 calender month (30 days = 1 month in computing interest)

365 days	= 1 year	366 days	= 1 leap year

Circular Measure

60 seconds	= 1 minute	90 degrees	= 1 quadrant
60 minutes	= 1 degree	360 degrees	= 1 circumference

Instead of an angle being given in degrees it can be given in radians, one radian being equal to the arc of a circle whose length is the radius. Thus if R denotes the radius, the circumference of the circle 2π R, then the circular measure of 90 $= \frac{\frac{1}{4} \times 2\pi R}{R} = \frac{\pi}{2}$; similarly the circular measure of $180° = \pi$; $60° = \frac{\pi}{3}$ &c.

Dry Measure

2 pints	= 1 quart	4 pecks	= 1 bushel
8 quarts	= 1 peck	36 bushels	= 1 chaldron

One United States struck bushel contains 2150.42 cu. ins. or 1.244 cu. ft. A British bushel contains 2218.19 cu. ins. or 1.2837 cu. ft. or 1.032 U. S. bushels.

Liquid Measure

4 gills	= 1 pint	$31\frac{1}{2}$ gallons	= 1 barrel
2 pints	= 1 quart	2 barrels or 63 gallons	= 1 hogshead
4 quarts	= 1 gallon		

One United States gallon contains 231 cu. ins. or .134 cu. ft. or 1 cu. ft. = 7.481 gallons. One British Imperial gallon both liquid and dry contains 277.27 cu. ins. or .160 cu. ft.

Board Measure

To find the number of feet board measure in a stick of timber, multiply the length in feet, by the breadth in feet, by the thickness in inches.

Example. Find the board measure of a piece of timber 20 ft. long, 2 ft. wide by 2 ins. thick.

20 ft. × 2 ft. × 2 ins. = 80 ft. board measure

Cubic Measure

1,728 cubic inches	=	1 cubic foot
27 cubic feet	=	1 cubic yard
128 cubic feet	=	1 cord of wood

Surveyor's or Gunter's Measure

7.92 inches	=	1 link	4 rods	=	1 chain
25 links	=	1 rod	80 chains	=	1 mile

Metric System

The fundamental units are—meter for length, liter for volume and gram for weight. Multiples are obtained by prefixing deka (10), hekto (100) and kilo (1,000), and divisions by deci (1/10), centi (1/100) and milli (1/1000). Abbreviations of the multiples begin with a capital letter, and of the divisions with a small.

Measures of Length

10 millimeters (mm.)	=	1 centimeter	cm.
10 centimeters	=	1 decimeter	dm.
10 decimeters	=	1 meter	m.
10 meters	=	1 dekameter	Dm.
10 dekameters	=	1 hektometer	Hm.
10 hektometers	=	1 kilometer	Km.

Measures of Surface (not Land)

100 square millimeters ($mm.^2$)	=	1 square centimeter	$cm.^2$
100 square centimeters	=	1 square decimeter	$dm.^2$
100 square decimeters	=	1 square meter	$m.^2$

Measures of Volume

1000 cubic millimeters ($mm.^3$)	=	1 cubic centimeter	$cm.^3$
1000 cubic centimeters	=	1 cubic decimeter	$dm.^3$
1000 cubic decimeters	=	1 cubic meter	$m.^3$

MEASURES OF CAPACITY

10 mililiters (ml.)	=	1 centiliter	cl.
10 centiliters	=	1 deciliter	dl.
10 deciliters	=	1 liter	l.
10 liters	=	1 dekaliter	Dl.
10 dekaliters	=	1 hekoliter	Hl.
10 hekoliters	=	1 kiloliter	Kl.

NOTE.—The liter is equal to the volume occupied by 1 cubic decimeter.

MEASURES OF WEIGHT

10 milligrams (mg)	=	1 centigram	cg.
10 centigrams	=	1 decigram	dg.
10 decigrams	=	1 gram	g.
10 grams	=	1 dekagram	Dg.
10 dekagrams	=	1 hektogram	Hg.
10 hektograms	=	1 kilogram	Kg.
1000 kilograms	=	1 ton	T.

NOTE.—The gram is the weight of one cubic centimeter of pure distilled water at a temperature of 39.2° F., the kilogram, is the weight of 1 liter of water, the ton is the weight of 1 cubic meter of water.

EQUIVALENT VALUES OF METRIC AND UNITED STATES (GREAT BRITAIN) MEASURES

MEASURES OF LENGTH

$$1 \text{ meter} = \begin{cases} 39.37 \text{ inches} \\ 3.28083 \text{ feet} \\ 1.0936 \text{ yards} \end{cases}$$

1 centimeter = .3937 inch

$$1 \text{ millimeter} = \begin{cases} .03937 \text{ inch, or} \\ 1/25 \text{ inch nearly} \end{cases}$$

1 kilometer = 0.62137 mile

1 foot = .3048 meter

$$1 \text{ inch} = \begin{cases} 2.54 \text{ centimeters} \\ 25.4 \text{ millimeters} \end{cases}$$

MEASURES OF SURFACE

$$1 \text{ square meter} = \begin{cases} 10.764 \text{ square feet} \\ 1.196 \text{ square yards} \end{cases}$$

1 square centimeter = .155 square inch.

1 square millimeter = .00155 square inch

1 square yard = .836 square meter

1 square foot = .0929 square meter

$$\text{1 square inch} = \begin{cases} \text{6.452 sq. centimeters} \\ \text{645.2 sq. millimeters} \end{cases}$$

MEASURES OF VOLUME AND CAPACITY

$$\text{1 cubic meter} = \begin{cases} \text{35.314 cubic feet} \\ \text{1.308 cubic yards} \\ \text{264.2 gallons (231 cubic inch)} \end{cases}$$

$$\text{1 cubic decimeter} = \begin{cases} \text{61.023 cubic inch} \\ \text{.0353 cubic feet} \end{cases}$$

1 cubic centimeter = .061 cubic inch

$$\text{1 liter} = \begin{cases} \text{1 cubic decimeter} \\ \text{61.023 cubic inches} \\ \text{.0353 cubic foot} \\ \text{1.0567 quarts (U. S.)} \\ \text{.2642 gallon (U. S.)} \\ \text{2.202 lbs. of water at } 62^\circ \text{ F.} \end{cases}$$

1 cubic yard = .7645 cubic meter

$$\text{1 cubic foot} = \begin{cases} \text{.02832 cubic meter} \\ \text{28.317 cubic decimeters} \\ \text{28.317 liters} \end{cases}$$

1 cubic inch = 16.393 cubic centimeters

1 gallon (British) = 4.543 liters

1 gallon (U. S.) = 3.785 liters

MEASURES OF WEIGHT

1 gram = 15.432 grains

1 kilogram = 2.2046 pounds

$$\text{1 metric ton} = \begin{cases} \text{.9842 ton of 2240 lbs.} \\ \text{19.68 cwts.} \\ \text{2204.6 lbs.} \end{cases}$$

1 grain = .0648 gram

1 ounce avoirdupois = 28.35 grams

1 pound = .4536 kilogram

$$\text{1 ton of 2240 lbs.} = \begin{cases} \text{1.016 metric ton} \\ \text{1016 kilograms} \end{cases}$$

MISCELLANEOUS

1 kilogram per meter = .6720 pounds per foot

1 gram per square millimeter = 1.422 pounds per square inch

1 kilogram per square meter = 0.2084 pounds per square foot

1 kilogram per cubic meter = .0624 pounds per cubic foot

1 degree centigrade = 1.8 degrees Fahrenheit
1 pound per foot = 1.488 kilograms per meter
1 pound per square foot = 4.882 kilograms per square meter
1 pound per cubic foot = 16.02 kilograms per cubic meter
1 degree Fahrenheit = .5556 degrees centigrade
1 Calorie (French Thermal Unit) = 3.968 B. T. U. (British Thermal Unit)

1 Horse Power = $\begin{cases}\text{33,000 foot pounds per minute}\\ \text{746 Watts}\end{cases}$

1 Watt (Unit of Electrical Power) = $\begin{cases}\text{.00134 Horse Power}\\ \text{44.22 foot pounds per minute}\end{cases}$

1 Kilowatt = $\begin{cases}\text{1000 Watts}\\ \text{1.34 Horse Power}\\ \text{44220 foot pounds per minute}\end{cases}$

Conversion Table of Inches and Feet to Millimeters, Centimeters and Meters

Inches	Feet	Millimeters	Centimeters	Meters	Inches	Feet	Millimeters	Centimeters	Meters
15/16	......	23.8	2.38	.023	14	.....	355.6	35.56	.355
1	......	25.4	2.54	.025	16	.....	406.4	40.64	.406
1 3/16	......	30.1	3.01	.030	18	1½	457.2	45.72	.457
1 7/16	......	36.5	3.65	.036	20	.....	508.0	50.80	.508
1½	......	38.1	3.81	.038	22	.....	558.8	55.88	.558
1 11/16	......	42.9	4.29	.042	24	2	609.6	60.96	.609
1 15/16	......	49.2	4.92	.049	26	.....	660.4	66.04	.660
2	......	50.8	5.08	.050	28	.....	711.2	71.12	.711
2 3/16	......	55.5	5.55	.055	30	2½	762.0	76.20	.762
2 7/16	......	61.9	6.19	.061	32	.....	812.8	81.28	.812
2½	......	63.5	6.35	.063	34	.....	863.6	86.36	.863
2 11/16	......	68.3	6.83	.068	36	3	914.4	91.44	.914
2 15/16	......	74.6	7.46	.074	38	.....	965.2	96.52	.965
3	......	76.2	7.62	.076	40	.....	1016.0	101.60	1.016
3 3/16	......	80.9	8.09	.080	42	3½	1066.8	106.68	1.066
3 7/16	......	87.3	8.73	.087	44	.....	1117.6	111.76	1.117
3½	......	88.9	8.89	.089	46	.....	1168.4	116.84	1.168
3 11/16	......	93.7	9.37	.093	48	4	1219.2	121.92	1.219
3 15/16	......	100.0	10.00	.100	50	.....	1270.0	127.00	1.270
4	......	101.6	10.16	.101	52	.....	1320.8	132.08	1.320
4 3/16	......	104.7	10.47	.104	54	4½	1371.6	137.16	1.371
4 7/16	......	111.3	11.13	.111	56	.....	1422.4	142.24	1.422
4½	......	114.3	11.43	.114	58	.....	1473.2	147.32	1.473
4 11/16	......	117.5	11.75	.117	60	5	1524.0	152.40	1.524
4 15/16	......	123.8	12.38	.123	62	.....	1574.8	157.48	1.574
5	......	127.0	12.70	.127	64	.....	1625.6	162.56	1.625
6	½	152.4	15.24	.152	66	5½	1676.4	167.64	1.676
7	......	177.8	17.78	.177	68	.....	1727.2	172.72	1.727
8	......	203.2	20.32	.203	70	.....	1778.0	177.80	1.778
9	......	228.6	22.86	.228	72	6	1828.8	182.88	1.828
10	......	254.0	25.40	.254		7	2133.6	213.36	2.133
11	......	279.4	27.94	.279		8	2438.4	243.84	2.438
12	1	304.8	30.48	.304		9	2743.2	274.32	2.743
						10	3048.0	304.80	3.048

Decimal Equivalents of an Inch and Millimeter-Inch Conversion Table

Fract.	Dec.	MM.	Fract.	Dec.	MM.
1/64	.015625	.397	33/64	.515625	13.1
1/32	.03125	.79	17/32	.53125	13.49
3/64	.046875	1.19	35/64	.546875	13.89
1/16	.0625	1.59	9/16	.5625	14.29
5/64	.078125	1.98	37/64	.578125	14.68
3/32	.09375	2.38	19/32	.59375	15.08
7/64	.109375	2.77	39/64	.609375	15.48
1/8	.125	3.17	5/8	.625	15.87
9/64	.140625	3.57	41/64	.640625	16.27
5/32	.15625	3.97	21/32	.65625	16.7
11/64	.171875	4.37	43/64	.671875	17.06
3/16	.1875	4.76	11/16	.6875	17.46
13/64	.203125	5.16	45/64	.703125	17.86
7/32	.21875	5.56	23/32	.71875	18.26
15/64	.234375	5.95	47/64	.734375	18.65
1/4	.25	6.35	3/4	.75	19.05
17/64	.265625	6.75	49/64	.765625	19.45
9/32	.28125	7.14	25/32	.78125	19.84
19/64	.296875	7.54	51/64	.796875	20.24
5/16	.3125	7.94	13/16	.8125	20.64
21/64	.328125	8.33	53/64	.828125	21.03
11/32	.34375	8.73	27/32	.84375	21.43
23/64	.359375	9.13	55/64	.859375	21.83
3/8	.375	9.52	7/8	.875	22.22
25/64	.390625	9.92	57/64	.890625	22.62
13/32	.40625	10.32	29/32	.90625	23.02
27/64	.421875	10.72	59/64	.921875	23.41
7/16	.4375	11.11	15/16	.9375	23.81
29/64	.453125	11.51	61/64	.953125	24.21
15/32	.46875	11.91	31/32	.96875	24.61
31/64	.484375	12.30	63/64	.984375	25
1/2	.5	12.7	1		25.4001

MM.	Dec. Inch	MM.	Dec. Inch
1	.039370	51	2.007892
2	.078740	52	2.047262
3	.118110	53	2.086632
4	.157480	54	2.126002
5	.196850	55	2.165372
6	.236220	56	2.204742
7	.275509	57	2.244112
8	.314960	58	2.283482
9	.354330	59	2.322852
10	.393704	60	2.362226
11	.433074	61	2.401596
12	.472444	62	2.440966
13	.511814	63	2.480336
14	.551184	64	2.519706
15	.590554	65	2.559076
16	.629924	66	2.598446
17	.669294	67	2.637816
18	.708664	68	2.677186
19	.748034	69	2.716556
20	.787409	70	2.755930
21	.826779	71	2.795300
22	.866149	72	2.834670
23	.905519	73	2.874040
24	.944889	74	2.913410
25	.984259	75	2.952780
26	1.023629	76	2.992150
27	1.062999	77	3.031520
28	1.102369	78	3.078090
29	1.141739	79	3.110260
30	1.181113	80	3.149635
31	1.220483	81	3.189005
32	1.259853	82	3.228375
33	1.299223	83	3.267745
34	1.338593	84	3.307115
35	1.377963	85	3.306485
36	1.417333	86	3.385855
37	1.456703	87	3.425225
38	1.496073	88	3.464595
39	1.535443	89	3.503965
40	1.574817	90	3.543339
41	1.614187	91	3.582709
42	1.653557	92	3.622079
43	1.692927	93	3.661449
44	1.732297	94	3.700819
45	1.771667	95	3.740189
46	1.811037	96	3.779559
47	1.850407	97	3.818929
48	1.889777	98	3.858299
49	1.929147	99	3.897669
50	1.968522	100	3.937043

Inches and Fractions in Decimals of a Foot

Inches and fractions	Decimals of a foot	Inches and fractions	Decimals of a foot	Inches and fractions	Decimals of a foot	Inches and fractions	Decimals of a foot
1/16	.0052	3 1/16	.2552	6 1/16	.5052	9 1/16	.7552
1/8	.0104	3 1/8	.2604	6 1/8	.5104	9 1/8	.7604
3/16	.0156	3 3/16	.2656	6 3/16	.5156	9 3/16	.76562
1/4	.0208	3 1/4	.2708	6 1/4	.5208	9 1/4	.77080
5/16	.0260	3 5/16	.2760	6 5/16	.5260	9 5/16	.77600
3/8	.0312	3 3/8	.2812	6 3/8	.5312	9 3/8	.78125
7/16	.0364	3 7/16	.2865	6 7/16	.5364	9 7/16	.7865
1/2	.0417	3 1/2	.2917	6 1/2	.5417	9 1/2	.7917
9/16	.0468	3 9/16	.2968	6 9/16	.5468	9 9/16	.7968
5/8	.0521	3 5/8	.3021	6 5/8	.5521	9 5/8	.8021
11/16	.0573	3 11/16	.3073	6 11/16	.5573	9 11/16	.8073
3/4	.0625	3 3/4	.3125	6 3/4	.5625	9 3/4	.8125
13/16	.0677	3 13/16	.3177	6 13/16	.5677	9 13/16	.8177
7/8	.0729	3 7/8	.3229	6 7/8	.5729	9 7/8	.8229
15/16	.0781	3 15/16	.3281	6 15/16	.5781	9 15/16	.8281
1	.0833	4	.3333	7	.5833	10	.8333
1 1/16	.0885	4 1/16	.3385	7 1/16	.5885	10 1/16	.8385
1 1/8	.0937	4 1/8	.3437	7 1/8	.5937	10 1/8	.8437
1 3/16	.0990	4 3/16	.3490	7 3/16	.5990	10 3/16	.8490
1 1/4	.1042	4 1/4	.3542	7 1/4	.6042	10 1/4	.8542
1 5/16	.1093	4 5/16	.3593	7 5/16	.6093	10 5/16	.8593
1 3/8	.1146	4 3/8	.3646	7 3/8	.6146	10 3/8	.8646
1 7/16	.1198	4 7/16	.3698	7 7/16	.6198	10 7/16	.8698
1 1/2	.1250	4 1/2	.3750	7 1/2	.6250	10 1/2	.8750
1 9/16	.1302	4 9/16	.3802	7 9/16	.6302	10 9/16	.8802
1 5/8	.1354	4 5/8	.3854	7 5/8	.6354	10 5/8	.8854
1 11/16	.1406	4 11/16	.3906	7 11/16	.6406	10 11/16	.8906
1 3/4	.1458	4 3/4	.3958	7 3/4	.6458	10 3/4	.8958
1 13/16	.1510	4 13/16	.4010	7 13/16	.6510	10 13/16	.9010
1 7/8	.1562	4 7/8	.4062	7 7/8	.6562	10 7/8	.9062
1 15/16	.1615	4 15/16	.4114	7 15/16	.6615	10 15/16	.9115
2	.1667	5	.4167	8	.6667	11	.9167
2 1/16	.1718	5 1/16	.4218	8 1/16	.6718	11 1/16	.9218
2 1/8	.1771	5 1/8	.4271	8 1/8	.6771	11 1/8	.9271
2 3/16	.1823	5 3/16	.4323	8 3/16	.6823	11 3/16	.9323
2 1/4	.1875	5 1/4	.4375	8 1/4	.6875	11 1/4	.9375
2 5/16	.1927	5 5/16	.4427	8 5/16	.6927	11 5/16	.9427
2 3/8	.1979	5 3/8	.4479	8 3/8	.6979	11 3/8	.9479
2 7/16	.2031	5 7/16	.4531	8 7/16	.7031	11 7/16	.9531
2 1/2	.2083	5 1/2	.4583	8 1/2	.7083	11 1/2	.9583
2 9/16	.2135	5 9/16	.4635	8 9/16	.7135	11 9/16	.9635
2 5/8	.2187	5 5/8	.4687	8 5/8	.7187	11 5/8	.9687
2 11/16	.2240	5 11/16	.4740	8 11/16	.7240	11 11/16	.9740
2 3/4	.2292	5 3/4	.4792	8 3/4	.7292	11 3/4	.9792
2 13/16	.2343	5 13/16	.4843	8 13/16	.7343	11 13/16	.9843
2 7/8	.2395	5 7/8	.4896	8 7/8	.7396	11 7/8	.9896
2 15/16	.2448	5 15/16	.4948	8 15/16	.7448	11 15/16	.9948
3	.2500	6	.5000	9	.7500	12	1.0000

Strength of Materials

Stresses per Square Inch

Material	Stresses in thousands of pounds					Modulus of elasticity pounds	Elongation %
	Tension ultimate	Elastic limit	Compression ultimate	Bending ultimate	Shearing ultimate		
Aluminum, cast	15	6.5	12		12	11,000,000	
Aluminum, wire	30–65	16–30					
Aluminum bronze, 5 to 7½ al	75	40	120				
Brass, cast	18–24	6	30	20	36	9,000,000	
Brass, wire	80						
Bronze, manganese cast, 10% tin, 2% mn	60	30	125				
Bronze, manganese rolled, 10% tin, 2% mn	100	80					
Bronze, phosphor cast, 9% tin, 1% P	50	24					
Bronze, phosphor wire, 9% tin, 1% P	100						
Bronze, Tobin, cast, 38% zinc, 1½% tin, ½% P	66						
Bronze, Tobin, rolled, 38% zinc, 1½% tin, ½% P	80	40				4,500,000	
Bronze, 8% tin	28.5	19	42	43.7		10,000,000	5.5
Cast iron, common	15–18	6-	80	30	18–20	12,000,000	
Cast iron, gray	18–24			25–33			
Cast iron, malleable	27–35	15–20	46	30	40		
Copper, cast	25	6	40	22	30	10,000,000	
Copper, wire	55–65					18,000,000	
Steel shapes	58–68	½ tensile	tensile	tensile	¾ tensile	29,000,000	25.9–22.1
Steel rivets	55–65	½ tensile	tensile	tensile	¾ tensile	29,000,000	27.3–23.0
Steel castings (medium)	70	31.5	tensile	tensile	¾ tensile	29,000,000	18
Wrought iron	48	26	tensile	tensile	5-6 tensile	28,000,000	

Specific Gravities and Weights of Materials

METALS AND ALLOYS

Substance	Specific gravity	Wt. per cu. ft. lbs.	Substance	Specific gravity	Wt. per cu. ft. lbs.
Aluminum, cast-hammered	2.6	165	Nickel	8.9	537
Aluminum, bronze	7.7	481	Platinum, cast-hammered	21.5	1330
Brass, cast-rolled	8.5	534	Silver, cast-hammered	10.5	656
Bronze, 7.9 to 14% tin	7.4–7.9	509	Steel, tool	7.72	459
Copper, cast-rolled	9.0	556	Steel, cast		
Gold, cast-hammered	19.3	1205	Tin, cast-hammered	7.3	459
Iron, cast	7.2	450	Zinc, cast-rolled	7.1	440
Iron, wrought	7.6–7.9	485			
Lead	11.37	710			
Manganese	7.2–8.0	475			
Mercury	13.6	849			

Timber, U. S. Seasoned
15 to 20% moisture

Substance	Specific gravity	Wt. per cu. ft. lbs.	Substance	Specific gravity	Wt. per cu. ft. lbs.
Ash, white-red	.62–.65	40	Maple, white	.53	33
Cedar, white-red	.32–.38	22	Oak, live	.95	59
Chestnut	.66	41	Oak, chestnut	.86	54
Cypress	.48	30	Pine, Oregon	.51	32
Fir, Douglas	.51	31	Pine, white	.41	26
Fir, Eastern	.40	25	Pine, long leaf yellow	.70	44
Hemlock	.5	29	Pine, short leaf yellow	.61	38
Hickory	.6–.9	48	Spruce	.44	27
Locust	.6–.7	46	Teak, African	.98	62
Mahogany	.5–.8	44	Walnut, black	.61	38

MISCELLANEOUS MATERIALS

Substance	Specific gravity	Wt. per cu. ft. lbs.	Substance	Specific gravity	Wt. per cu. ft. lbs.
Water, fresh, 4° C max. dens	1.0	62.42	Petroleum, gasoline	.7–.75	45
Water, salt	1.02–1.03	64	Cement, Portland, loose	1.4	90
Ice	.88–.93	57	Coal, anthracite	1.4–1.7	97
Petroleum	.87	54	Coal, bituminous	1.2–1.5	84

Equivalent Values of Mechanical, Electrical and Heat Units

Unit	Equivalent value in other units
1 Ft. lb.	1.3558 joules .0000003766 K. W. hour .0012861 B. T. U.
1 H. P.	745.7 watts .7457 K. W. 33,000 ft. lbs. per min. 42.44 B. T. U. per min. 2.62 lbs. water evap. per hour from and at 212 degs. F.
1 Kilowatt	1,000 watts 1.3410 horse power 44,253 ft. lbs. per min. 56.92 B. T. U. per min. 3.52 lbs. water evap. per hour from and at 212 degs. F.
1 Joule	1 watt second .000000278 K. W. hour .0009486 B. T. U. .73756 ft. lb.
1 lb. of water evap. from and at 212 degs. F.	.2841 K. W. hour .3811 H. P. hour 970.4 B. T. U. 1,023,000 joules 754,525 ft. lbs.
1 B. T. U.	1,054.2 watt seconds 777.54 ft. lbs. .0002928 K. W. hour .0003927 H. P. hour

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